Data Acquisition & Processing Report

Type of Survey: Benthic Habitat and Hydrographic

Project No. NF-05-05-USVI

Time Frame: February 01-12, 2005

Locality

U.S. Virgin Islands

General Locality: South of St. John and St. Thomas and Buck Island, St. Croix

2005

Chief Scientist

Timothy A. Battista

Lead Hydrograher

John V. Lazar, Jr.

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Table of Contents

I. Background	**1**
II. Area	**1**
III. Equipment	**2**
IV. Quality Control	**6**
V. Corrections to Echo Soundings	**8**
VI. Statement of Accuracy and Suitability for Charting	**12**
VII. Submitted Data and Reports	**18**
Approval Sheet	**19**
Appendix A. Cruise Instructions	**20**
Appendix B. Centerline Survey	**35**
Appendix C. Tides Report	**42**
Appendix D. Patch Test Report	**46**
Appendix E. Hardware and Software Settings	**55**
Appendix F. Vessel Offset Diagrams	**67**
Appendix G. Hare Analysis Vessel Configuration Worksheets	**69**

List of Figures

Fig. 1. St. Croix survey areas	**1**
Fig. 2. St. John and St. Thomas survey areas	**1**
Fig. 3. Side view of sensor offsets	**2**
Fig. 4. Plan view of sensor offsets	**2**
Fig. 5. Reson 8101 Seabat Sonar	**3**
Fig. 6. Refabricated steel pole mount	**3**
Fig. 7. POS MV antenna placement	**4**
Fig. 8. POS MV antenna placement	**4**
Table 3.1 Sensor Inventory	**5**
Table 3.2 Software Inventory	**5**
Fig. 9. Multibeam Processing Pipeline	**6**
Fig. 10. St. Croix combined survey areas	**7**
Fig. 11. St. John and St. Thomas survey areas	**7**
Table 5.1. Sensor Offset Table	**9**
Fig. 11. Shallow water patch site	**10**
Fig. 12. Deep water patch site	**11**
Fig. 13. ISS2000 Setup parameters	**12**
Fig. 14. CTD Comparison	**14**
Table 6.1. 2005 Mileage Summary	**17**

Data Acquisition and Processing Report

Cruise Number NF-05-05-USVI

NOAA Ship Nancy Foster

St. Croix, St. John, and St. Thomas, U.S. Virgin Islands
Chief Scientist: Tim Battista
Lead Hydrographer: Jay Lazar

I. Background

In June 1998, the U.S. Coral Reef Task Force (USCRTF) was established by Presidential Executive Order 13089. The mission is to lead, coordinate, and strengthen U.S. government actions to better preserve and protect coral reef ecosystems. The National Oceanic and Atmospheric Administration's (NOAA) Center for Coastal Monitoring and Assessment (CCMA) Biogeography Team is supporting the USCRTF mandate. The Biogeography Team conducted the second year of an ongoing scientific research mission on board the NOAA Ship NANCY FOSTER from February 1 to February 12, 2005. The purpose of this cruise is to support the benthic characterization of coral reef habitat in the U.S. Virgin Islands.

II. Area

This joint mission with the National Park Service (NPS), the National Marine Fisheries Service (NMFS), and the US Virgin Islands government explored and characterized moderate depth habitats (<300 meters) within the U.S. Virgin Islands for natural resource management. Priority areas for 2005 include NPS's Virgin Islands Coral Reef National Monument, NPS's Buck Island National Monument, Salt River Bay National Historical Park and Ecological Reserve, and the NMFS Grammanik Bank system south of St. Thomas. The area designated NPS Inshore immediately south of St. John was chosen as a benthic habitat mapping/ hydrographic charting survey demonstration site. As such, additional considerations were made to meet the International Hydrographic Organization (IHO) Level One survey standards. The two figures below, Figure 1 and 2 identify the targeted survey areas. The coordinates bounding the area south of St. Johns and St. Thomas are 18°20'N and 65°00'W to the northwest and 18°10'N and 64°39'W to the southeast. The coordinates bounding the St.Croix area are 17°51'N, 64°46'W to the northwest and 17°46'N, 64°33'W to the southeast.

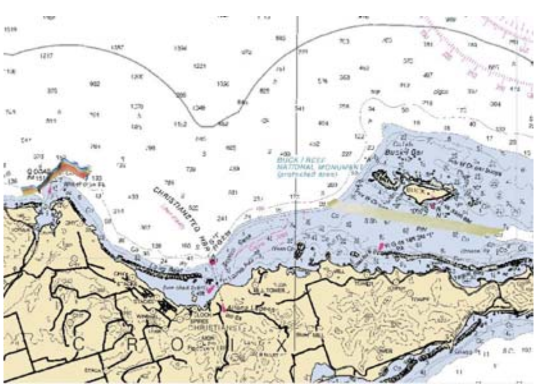


Figure 1. St. Croix survey areas

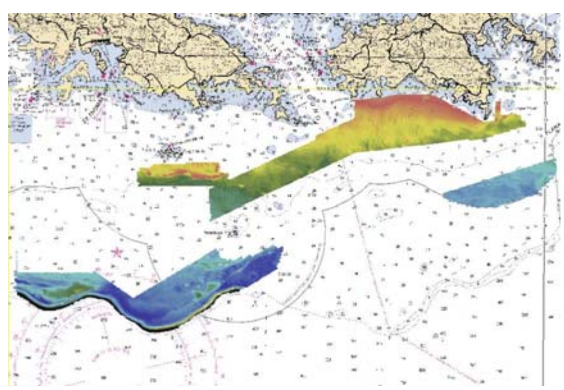


Figure 2. St. Johns and St. Thomas survey areas.

III. Equipment

Vessel

The NOAA Ship Nancy Foster provided an adequate platform for the acquisition of high-resolution shallow water multibeam and backscatter data. The Nancy Foster is 56.8 meters in length with a beam of 12 meters and a draft of 3.2 meters. Her steel pole sonar mount (Figure 6) was re-fabricated from previous missions to deliver a more rigid support system for multibeam operations. The steel schedule was tripled from 40 to 120 and the diameter was increased from 3 to 4 inches. Additionally, new antenna mounts were designed and installed to accommodate the integrated GPS and inertial motion reference unit (MRU). The sensor offsets can be identified in the following images, Figures 3 and 4 and in Appendix F. An electric winch spooling steel cable through the block of a J-Frame davit provided a consistent rate of descent for the acquisition of sound velocity data.

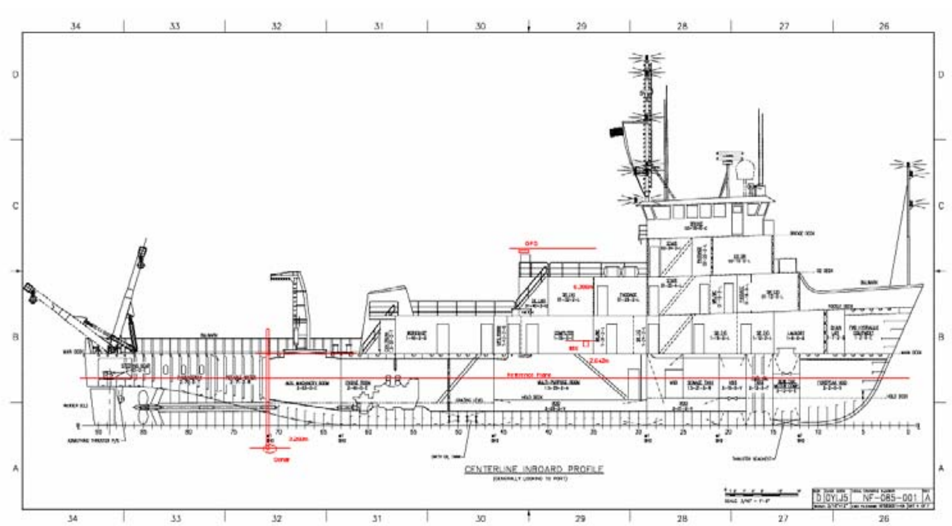


Figure 3. Side view of sensor offsets

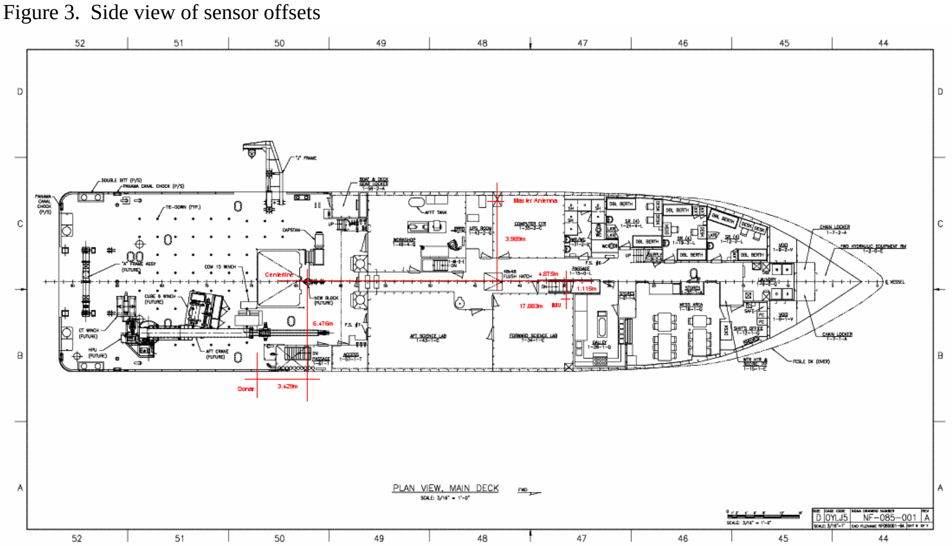


Figure 4. Plan view of sensor offsets

Sonar System

A Reson SeaBat 8101 Extended Range (ER) Multibeam Echosounder System (Figure 5) was pole-mounted to the Nancy Foster to continue the benthic habitat mapping initiated last season. This particular system was loaned from NOAA's NMFS Pacific Island Fisheries Science Center (PIFSC) Coral Reef Ecosystem Division (CRED). The crew of the Research Vessel AHI provided the sonar system and motion sensor calibration documentation. With the side scan sonar Option 033, where both the transducer and processor are upgraded to measure, process, and output multibeam backscatter imagery in "standard" and "Snippets" formats, the sonar will be able to identify structure not available to direct sounding measurements. The 8101 is also upgraded with Option 037, the titanium housing and Option 040, the extended range projector.

Figure 5. Reson 8101 Seabat Sonar

Figure 6. Refabricated steel pole mounted to starboard

The SeaBat 8101 ER is a 240 kHz multibeam system that measures relative water depths across a 150^{o} swath, consisting of 101 individual 1.5^{o} x 1.5^{o} beams. This system is used to obtain full-bottom coverage in depths less than 300 meters, with range scale values dependent upon the depth of water and across-track slope. The concept of "full bottom coverage" will be discussed in more detail in section IV. The sonar was set to transmit a maximum ping rate of 30 pings per second. Actual ping rates varied between four pings per second in the deepest areas of the shelf to 20 pings per second in the most shoal survey lines. The ping rate is a direct reflection of the range scale occupied by the sonar. This ping rate translated to an ensonification of 1.3 pings per meter at the deeper range settings and 6.7 pings per meter in the lower range settings. The time varied gain (TVG) setting was enabled with Auto Gains set to 1. The transmit pulse width was set to 79 microseconds. A variety of ranges were used during acquisition, however the 200m or less ranges dominated the majority of survey times. Since TVG gains were applied, the Ocean Menu settings are also pertinent. A spreading loss of 30 log decibels and absorption value of 70 decibels per kilometer were identified as general values for working in seawater. There were no filters applied to the sonar during acquisition. Versions of hardware and software follow in Tables 3.1 and 3.2. Sensor settings are documented in *Appendix E.*

Motion Reference Unit

The POS/MV Model 320 is a GPS aided inertial measurement unit (IMU) that generates attitude data in three axes. Measurements of roll, pitch and heading are all accurate to $\pm$ 0.02° or better, regardless of the vessel latitude. Heave measurements supplied by POS/MV maintain an accuracy of 5% of the measured vertical displacement or ± 5cm (whichever is the larger) for movements that have a period of up to 20 seconds. The accuracy and stability of measurements delivered by the system remain unaffected by vessel turns, changes of speed, wave-induced motion, or other dynamic maneuvers. Position and motion data were supplied to the acquisition system via Ethernet cable allowing for the highest update rate. No less than 25 Hz was supplied to the ISS system. Com Port 2 was configured to supply motion data to the Reson sonar for real-time motion corrected depth gating if the Hydrographer determined it was needed. The heave bandwidth was set to 20.0 seconds with a dampening ration of .707. Roll, pitch, and heave positive sense were port up, bow up, and heave up respectively. Multipath was set to medium due to the placement of the two GPS antennae aft and below the bridge. Software and hardware versions follow. Sensor settings are documented in *Appendix E.*

Positioning System

The POS/MV Model 320 combined GPS and motion sensor was installed temporarily by the Hydrographer. A clear horizon and rigid mounting frame were considered during the site selection for the antennae. The two GPS antennae each provide corrections for their associated receivers. The primary receiver can receive and process differential corrections. This receiver provides the position and velocity information to POS/MV. It also provides the 'Pulse per second' (PPS) strobe that POS/MV uses to synchronize data output to UTC or GPS time. The secondary receiver allows POS/MV to compute GPS heading aided by performing carrier phase differential measurements between the two GPS receivers achieving an accuracy to ± 0.02° or better in low latency environments. Position data was transmitted via an Ethernet connection but was digitally logged to the ISS system per depth measurement. Therefore, position data points are only as frequent as the sounding data.

Figure 7. Master POS MV antenna is on your left, the starboard antenna.

Figure 8. POS MV antennae looking forward

The Nancy Foster receives differential GPS positions from two Northstar 941X GPS Navigator antennae on top of the pilothouse. Both the port and starboard systems receive differential corrections internally with published accuracies of 1-3 meters. Both permanent systems are involved with the survey . The port Northstar receiver will provide the differential corrections to the POS/MV and the starboard Northstar receiver will have its position recorded with the acquisition software to log redundant observations. Each receiver was configured to manually lock to frequency 295.0 kHz, the Port Isabel, San Juan Continually Operating Reference Station (CORS) beacon.

Sound Velocity

The primary instrument for determining sound velocity is a Seabird Electronics SBE-19P Conductivity, Temperature, and Depth (CTD) gauge. A second SBE-19 was used for calibration and could be deployed in the event of the primary system failure. Data was recorded frequently, as 4-5 records per meter were logged. Sound velocity casts were processed with Seabird Seaterm software and applied real-time as an SVP file to the raw generic sensor format (GSF) data.

Acquisition System

The SAIC ISS 2000 acquisition platform was provided for data collection during this project. This platform integrated the sensor data streams, applied sound velocity corrections real-time, applied predicted tides and eliminated those beams beyond 70° for all survey areas except NPS Inshore. NPS Inshore eliminated beams beyond 60°. Line spacing was determined by depth and was kept to approximately three times the water depth for the NPS Inshore area and up to 4 times the water depth in the other survey areas. A two-meter coverage grid was updated real-time with the ISS system to monitor the survey for gaps in coverage. The coverage grid had the potential to identify problems with the patch test values since the data was motion, tide and sound velocity corrected. Line planning occurred with the Survey Planning module of the ISS software.

Computer Hardware/Software Specifications

Sensor Inventory		
Sensor	**Firmware**	**Serial Number**
Reson Seabat 8101(sonar)	Wet 8101-1.06-2F6B	201004
Reson Seabat 8101(deck)	Dry 8101-2.07-2D4D	29982
POS/MV 320	2.16	474
Seabird SBE 19P (1°)	NA	19P29986-4282
Seabird SBE 19-01	NA	1917166-2530
Northstar 941X (P)	NA	AJ16496D
Northstar 941X (S)	NA	AJ16547D

Table 3.1

Software Inventory		
Software	**Version**	**Date**
POS/MV Controller	V3 2.1	9/13/2000
SeaTerm	1.33	12/20/2002
Caris HIPS	5.4.1.11 Hotfix 20	4/12/2004
ISS2000	3.4.4	1/16/2004

Table 3.2

IV. Quality Control

The following flow diagram (Figure 9) provides a guide for detailing the process of reducing the raw soundings to their final corrected value.

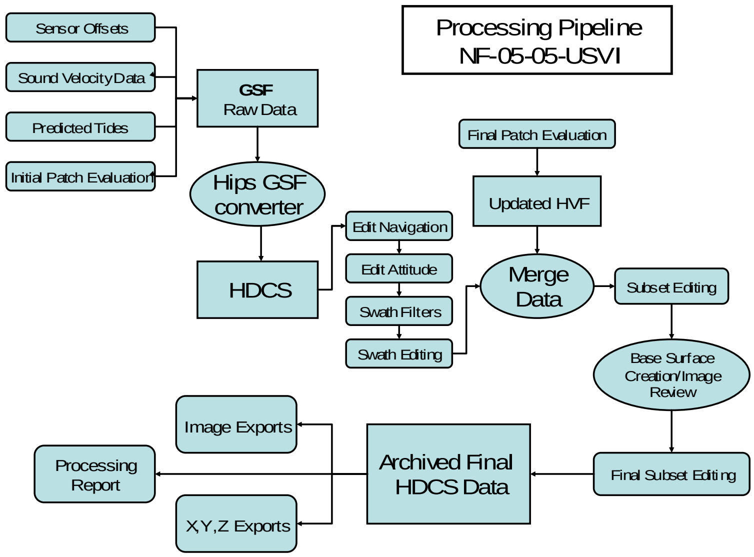


Figure 9. Multibeam Processing Pipeline

The SAIC generic sensor format (GSF) raw multibeam data arrives corrected for sound velocity, with predicted tides, and the preliminary patch test values applied. The Caris Hips Conversion Wizard used the GSF converter to create the Hips format processed data files in the North American Datum of 1983, Universal Transmercator Zone 20, Northern Hemisphere (NAD83 UTM20N). The ISS2000 system acquires the GSF format with either an online or an offline flag attached to the data. All survey lines with the exception of the NPS Inshore lines flagged those soundings beyond 70° as reconnaissance data. The NPS Inshore area used the 60° cutoff for data acquisition. All data but the final day of acquisition was converted and preliminary processing occurred in the field.

Preliminary data processing or the initial phase consists of three steps: navigation editing, attitude editing, and swath data editing. Navigation edits included reviewing for time jumps of greater than 0.2 seconds and removing data in turns. Attitude data was reviewed for gaps and none were identified. Swath data was converted without filtering. Filtering of swath data occurred prior to editing and was used to eliminate large outliers in the water column. The beams rejected were the zero (0) beam quality flag and different minimum and maximum depths. The minimum and maximum depths filtered varied by survey area. Swath-edit mode efficiently removed fliers as well as down slope beams where the survey lines crossed over the shelf escarpment providing unreliable soundings. Swath editing is conducted one line at a time.

As stated, efficient handling of data processing in the field afforded the opportunity to initiate review of the areas surveyed in Hips Subset Editor, the second phase of editing. Subset editing enabled the hydrographer to evaluate each line against its neighbors while identifying potential tide and motion artifacts. The verification of features from adjacent lines as well as feature alignment occurs in subset edit mode. The second step is the review of base surfaces for coverage and systematic errors or artifacts. The BASE surface routine produced sun-illuminated imagery that was created for final surface evaluation prior to the final archival and production of deliverables. The weight a sounding contributes to the BASE surface varies by the sounding's grazing angle with the seafloor. In an area with overlapping survey lines, the grazing angle weight ensures that a higher weight priority is given to beams from the inner part of a swath than to outer beams from adjacent survey lines. Soundings with an angle between 90 and 75 degrees are given a weight of 1.0. The weight decreases linearly to 0.01 as the grazing angles with the seafloor decreases to 15 degrees. Final processing of the datasets was completed by the Contract Lead Hydrographer post field operations. The BASE surface images were reviewed with multiple resolutions, sun angles, sun azimuths and vertical exaggerations. The base surface routine produced images identifying Depth, Shoal-biased depth, Deep-biased depths, Mean depths, Standard Deviation, sounding Density, and depth Uncertainty. The following two images depict the areas surveyed and illuminated by the Depth base surface. The grey-scale areas are from the 2004 survey.

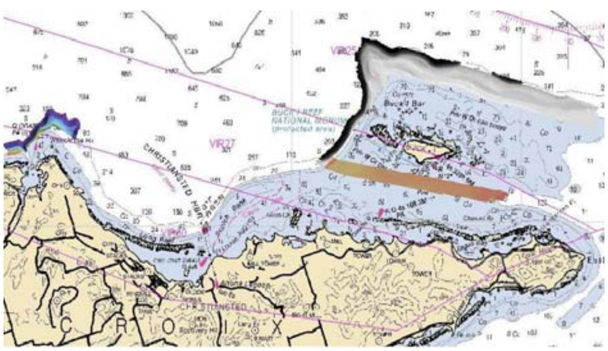


Figure 10. St. Croix survey areas

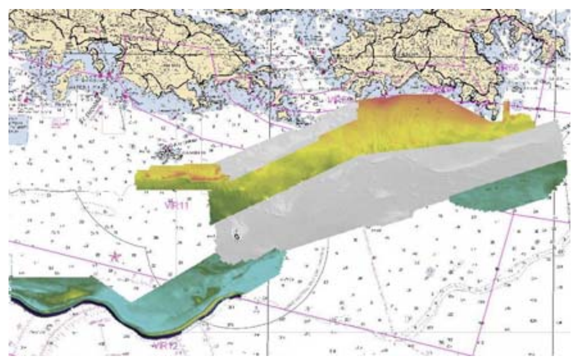


Figure 11. St. Thomas and St. Johns survey areas

Fine image resolutions were built to measure our success of achieving “full bottom coverage” in a survey area. Section 5.2.2 of the National Ocean Service’s Specifications and Deliverables document determines full bottom coverage to be shown as the location of “3.2 beam footprints, center-to-center, fall within 3 meters, or a distance equal to 10 percent of the depth, whichever is greater in the along track direction”. The Hydrographer managed ping rates against vessel speeds during acquisition to keep the survey within these specifications. Hence a 1-meter grid resolution adequately demonstrates this requirement in depths less than 30 meters and was used in the MSR, Buck Channel and NPS Inshore survey areas. With our deepest survey depths on the shelf reaching 58 meters, a 2-meter grid demonstrated full bottom coverage in the NPS Offshore, Salt River, and Grammanik Bank survey areas. Geo-referenced images of the Depth base surface produced with 24-bit color and xyz exports produced with the Hips Export Wizard at the fine resolution for the survey area were also derived from the Depth BASE surface. A final quality control analysis was performed on reference surfaces using the Hips Quality Control Report. For this report, each available beam from a minimum of one line collected perpendicular to the predominant survey line azimuth was analyzed against a 3m grid of the reference surface. Results of the analysis of four survey areas are presented in *Separate C*.

V. Corrections to Echo Soundings

Instrument corrections

An initial bar check and leadline confidence check were measured against the Reson Seabat 8101 multibeam echosounder prior to the start of field operations. The purpose of these two checks was to calibrate the system to the in situ conditions and to verify that the digital depths being recorded reflected the actual depths observed. The bar check resulted in a 3cm difference. Several factors may have contributed to this difference. Survey tape placement onto the bar, the short distance to the bar beneath the sonar, and the measurement of the distance to the sonar on the pole could each account for 1cm. The leadline followed and resulted in a difference of 1cm between the observed distance to the seafloor and the resulting digital depth recorded. These initial confidence checks were the only opportunity to make the comparisons in calm water. No instrument error correction was applied because of insufficient evidence of a systematic error.

Sensor Offsets

On January 15, 2005 the NOAA Ship Nancy Foster had her sensor offsets surveyed by Kendall Fancher of National Geodetic Survey (NGS). The values obtained from the survey are documented in *Appendix B*. Reference marks created during the Sensor Offset Survey were then used to obtain final offsets once the actual sensors were secured to the vessel. These offsets were entered into the ISS 2000 acquisition software and the POS/MV software and are recorded into the GSF data files. These offsets will not be entered as sensor offsets in the Caris Hydrographic Vessel File *NF_2005_zero.hvf* but will be recorded in the Total Propagated Error (TPE) parameter information. Screen grabs of the settings used for the motion reference unit, the sonar, and the acquisition system documenting offsets and system specific parameters are included as *Appendix E.* The POS/MV frame of reference differs from the standard Cartesian coordinate system used in ISS 2000 by applying fore/aft offsets in the x-axis and port/starboard offsets in the y-axis, with positive values forward and starboard. The z-plane is positive down. The following image is a copy of the Excel spreadsheet created to document the Centerline survey and to show how the offset values entered into the POS MV and the ISS2000 acquisition system were derived.

NOAA SHIP NANCY FOSTER

STATION COORDINATES

These coordinates are in POS/MV ref. frame

		OBSERVED			COORDINATES			COORDINATES ref to MB pole center		
ID	NAME	EASTING	NORTHING	UP	EASTING	NORTHING	UP	Y	X	Z
CL01	CENTERLINE POINT 1	1000.000	1000.000	1000.000	0.000	0.000	0.000	-1.115	-17.883	0.642
CL02	CENTERLINE POINT 2	1000.000	987.203	999.847	0.000	-12.797	-0.153	-1.115	-30.680	0.795
TP01	TEMPORAY POINT 1	1003.514	1012.814	1000.407	3.514	12.814	0.407	2.399	-5.069	0.235
POLE	*MB Survey RP (center of pole)*				*6.476*	*-3.289*		5.361	-21.172	0.642
8101	*Acoustic Center of transducer*				*6.476*	*-3.429*	*-5.260*	**5.361**	**-21.312**	**5.902**
ARP	*Assumed center of motion*				*0.000*	*8.883*	*-2.000*	**-1.115**	**-9.000**	**2.642**
MB01	MULTIBEAM REFERENCE POIN	1005.943	996.711	1001.020	5.943	-3.289	1.020	4.828	-21.172	-0.378
MB02	MULTIBEAM REFERENCE POIN	1005.944	996.405	1001.016	5.944	-3.595	1.016	4.829	-21.478	-0.374
ROV1	ROV REFERENCE POINT	994.073	1000.147	1001.155	-5.927	0.147	1.155	-7.042	-17.736	-0.513
ROVG	ROV GPS ANTENNA	999.866	1002.380	1003.795	-0.134	2.380	3.795	-1.249	-15.503	-3.153
IMS	IMU GPS REFERENCE POINT	995.979	1012.779	1006.804	-4.021	12.779	6.804	-5.136	-5.104	-6.162
	Pos Gps master ant.(stbd)	996.011	1013.008	1007.028	-3.989	13.008	7.028	**-5.104**	**-4.875**	**-6.386**
IMP	IMU GPS REFERENCE POINT F	994.357	1012.779	1006.801	-5.643	12.779	6.801	-6.758	-5.104	-6.159
GPP	GPS ANTENNA PORT SIDE	996.991	1024.186	1012.032	-3.009	24.186	12.032	**-4.124**	**6.303**	**-11.390**
GPS	GPS ANTENNA STARBOARD S	1003.050	1024.308	1012.320	3.050	24.308	12.320	1.935	6.425	-11.678
IMU	IMU	1001.115	1017.883	1000.642	1.115	17.883	0.642	**0.000**	**0.000**	**0.000**

NOTE- THE NORTHING RUNS ALONG THE CENTERLINE OF THE SHIP IN A POSITIVE DIRECTION FROM CENTERLINE POINT 1 FORWARD TO THE FRONT OF THE SHIP.

NOTE- THE EASTING RUNS PERPENDICULAR TO THE CENTERLINE OF THE SHIP AND RUNS IN A POSITIVE DIRECTION TO THE RIGHT OF CENTERLINE POINT 1, WHEN LOOKING AT CENTERLINE POINT 1 FROM THE BACK OF THE SHIP.

NOTE: IMU ref point is 16.5" off main deck

NOTE- THE UP COMPONENT IS POSITIVE WHEN ABOVE THE LEVEL OF CENTERLINE POINT 1.

NOTE: On the transducer mount, the distance from midpoint between the top 2 mounting bolts and the acoustic center of the transducer is X = -0.134, Z = 0.303

NOTE- *Text in italics descibes points added by multibeam survey team after delivery of NGS field report*

Table 5.1 Sensor offset table

Static and Dynamic Draft Corrections

The static draft correction recorded on February 1 was of magnitude 3.34m. The final static draft recorded on February 12, 2005 was of magnitude 3.15m. Attempts to read the static draft occurred daily, however the sea state was not conducive to accurately record the changes in vessel loading. Therefore, the Hydrographer determined corrections based on the rates of fuel consumption and water discharge events using the relative weights of each liquid derived from volume calculations that take into account the specific gravity of each liquid. These values for change were interpolated in the overall decrease of the 0.19m of static draft. These draft corrections were applied during post-processing. Dynamic draft values at this time have not been determined for the NOAA Ship Nancy Foster. No dynamic draft values were entered into the HVF.

System Alignment and Calibrations

System Alignment and calibration procedures are documented in *Appendix D*, the NF-05-05-USVI Patch Test Report. On Julian Day 032 four lines of uncorrected multibeam data were collected along two transects east of Buck Island, St. Croix. Two lines on a reciprocal course upslope and over a sharp ledge provided the pitch offset, and the same lines run in a relatively flat area gave the roll bias. Offset to the initial transect was a single line to verify gyro bias. A final line was collected along the initial transect at slow speeds to identify timing error. The following image shows the initial patch test area as well as the coverage of the four patch test lines. The alignment bias can be observed in the contours during the initial patch test.

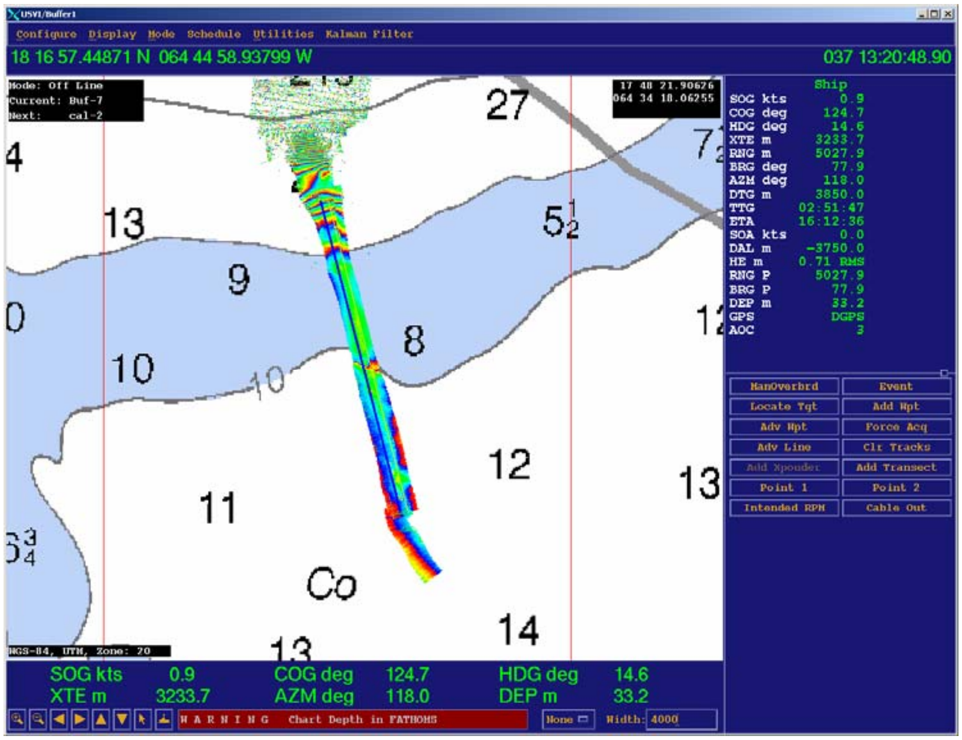


Figure 11. Initial Patch Site east of Buck Island on the northeastern tip of St. Croix

Zero timing error was identified. This is consistent with the POS/MV operation principles. A pitch offset of -2.1° was detected. A roll bias of +0.9° was identified. A gyro bias of -5.0° was determined. These values were entered into the *NF_2005_patch.hvf* while the ISS2000 software values were zeroed out. Prior to the start of surveying, these values were added to the acquisition software and were no longer used for CARIS data conversion. After the second line of data *nfmba05032.d26* was collected the ISS2000 system crashed. The survey resumed once the pc was brought online. The patch values were not present. This resulted in the following three data lines *nfmba05033.d05, d06, and d07* being acquired without the patch test values. Subsequently, those lines were converted into CARIS with the *NF_2005_patch.hvf*. The limiting factor to determining a more precise calibration was the depth of the area surveyed. The shoal depths result in a less than optimal calibration line set for observing bias. With that being said, the determined offsets proved to be pretty close to those determined in the deep-water calibration set performed on Julian Day 035. A second patch test was going to be needed and an ideal location was identified at the shelf break south of St. John. Coincidentally, after the Grammanik East survey watch, an artifact was observed during heavy seas surveying with considerable roll. The artifact was attributed to flex in the sonar pole. As a precautionary action, the pole was pivoted into its cradle and visually inspected. Upon completing the transit after the inspection, a deepwater modified patch test was conducted to both determine more precise bias offsets and ensure proper re-alignment. Three lines were run in a similar fashion to the initial three in the beginning patch test. Pitch and roll lines ran reciprocally over a reef crest and flat bottom. The gyro bias was again observed with a line ran offset and upslope as shown in the figure above. Minor adjustments to the initial determined values were made resulting in a pitch value of -1.8°, roll value of +0.83°, and gyro of –4.0°. The initial values remained in the acquisition software and the adjustments were to be applied in post-processing. The question to be answered was whether or not back applying the new values to the data collected prior to the pole inspection would be required.

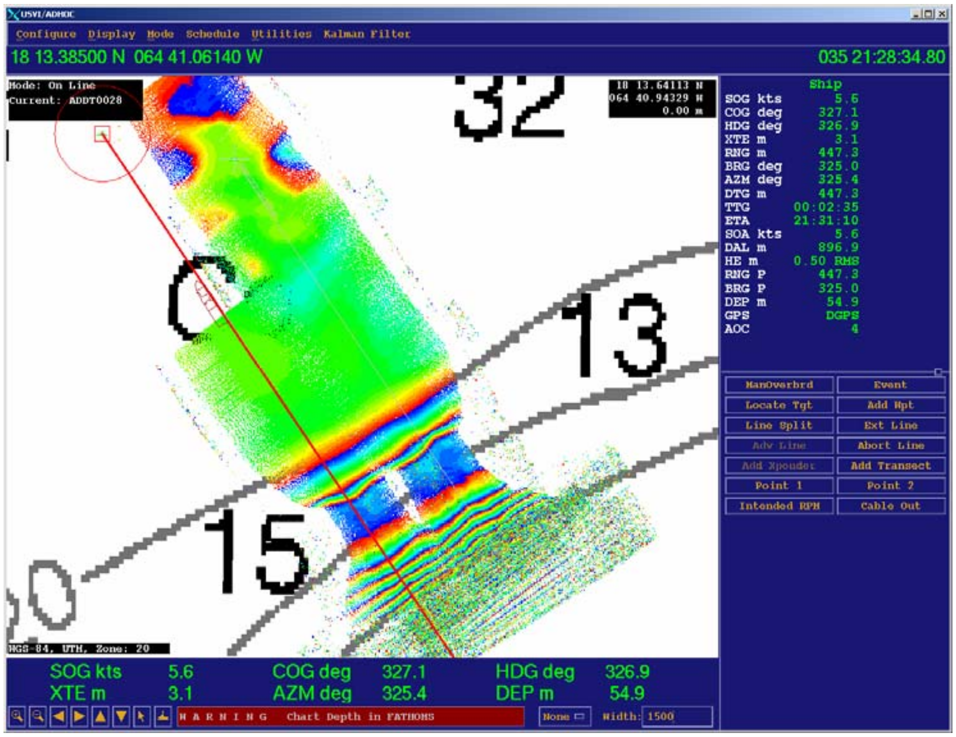


Figure 12. Deepwater Patch Site south of St. Johns

The Hydrographer tested the new values against the earlier data and determined that a noticeable improvement to feature alignment was observed and that the adjustments would be back applied to the entire dataset. This resulted in a change to the HVF and is observed in a new timestamp later than the initial stamp but prior to the start of acquisition. During testing, a problem with the processing software was detected. Apparently during conversion from raw multibeam to HDCS data, the gyro bias value was not being read. Considerable tests were conducted with varying gyro offsets to come to this conclusion. It is for this reason that the –4.0° gyro offset is being applied in the HVF and not the +1.0° adjustment between the initially determined offset and the adjusted value.

Tide Corrections

The Statement of Work developed by NOAA CO-OPS prior to the commencement of survey operations will be submitted as *Appendix C.* Existing water level stations were used in conjunction with height and time correctors in a tide zone definition file or ZDF.

VI. Statement of Accuracy and Suitability for Charting

Assessment of horizontal control

<u>Positioning equipment and methods</u>
The horizontal datum for this project is the North American Datum of 1983 Universal Transmercator Zone 20, Northern Hemisphere (NAD83 UTM20N). Differential GPS (DGPS) corrected positions were supplied to the POS/MV and monitored. Differential corrections were received from U.S. Coast Guard Continually Operating Reference Station (CORS) Isabel, Puerto Rico. Isabel operates at a frequency of 295.0 kHz. With the survey areas approximately 150 nautical miles from the reference station, occasional DGPS dropouts occurred. These signal losses were evaluated for the total time of drop out. The most likely cause of this infrequent signal loss is interference from the mountains between the location of the CORS site and the survey vessel. When signal loss occurred, positional accuracies calculated by the POS/MV were monitored in the POS/MV Controller software. Data were flagged in the acquisition software if positional tolerances were exceeded. These tolerances are displayed in the following image. The thirteen items associated with the POS subgroup of 'Quality' are associated with their tolerance values.

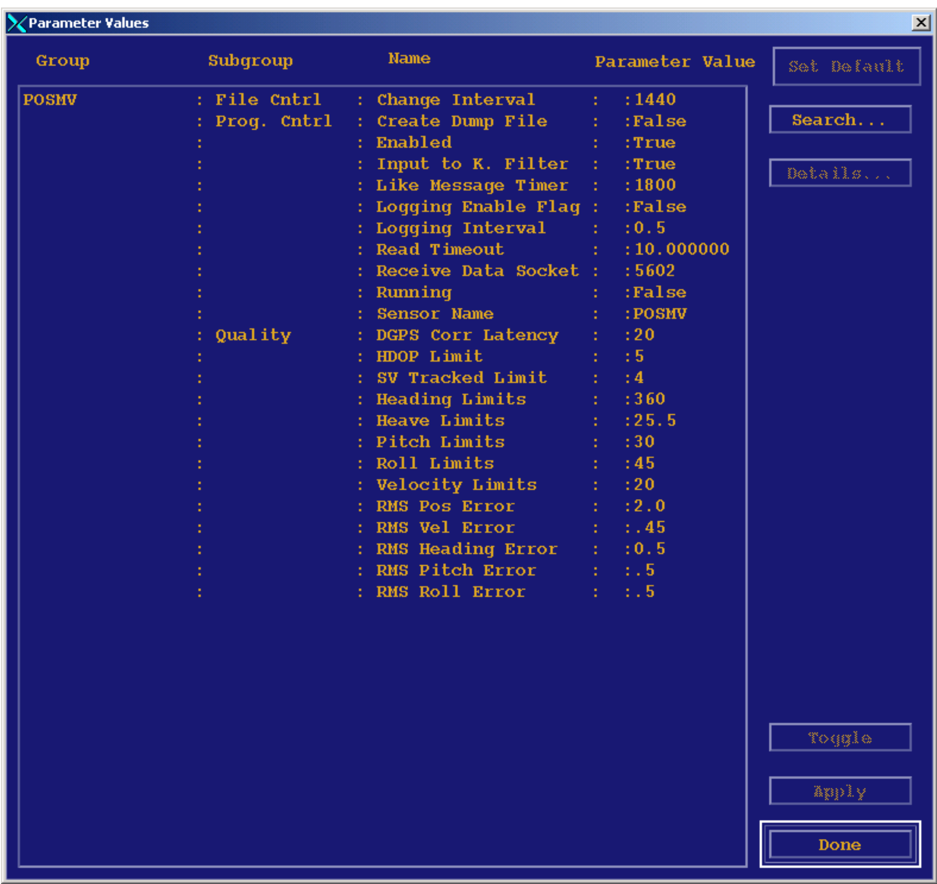


Figure 13. ISS2000 setup parameters relating to the POS MV

No positions were interpolated between DGPS signal loss, nor were survey lines removed from the survey. All flags pertaining to the signal loss remain in the raw data format.

Quality control
A position check between two independent DGPS systems was observed and recorded on February 02, 2005 while docked at the Molasses Pier, Port Alucroix. The POS/MV located sonar position, receiving differential corrections from the vessels port Northstar receiver, was compared to the positions being output for the starboard Northstar receiver. The GPS distance calculated between the two sensors was 29.51m. The distance calculated from the NGS survey was 29.20m.

Statement of accuracy and compliance with HSSDM
Based on a combination of the positioning system confidence check, real-time tolerance monitoring and fantastic seafloor feature alignment, the Hydrographer feels that the Horizontal Control should be considered adequate for the purposes of this survey.

Assessment of vertical control

Water level measuring equipment and methods
The Vertical Datum for this survey was Mean Lower-Low Water (MLLW). The National Water Level Observation Network (NWLON) primary tide stations at, Charlotte Amalie, VI (9751639) and Lime Tree Bay, VI (9751401) served as the primary sources for water level reducers for this survey. Six-minute predicted tides were obtained from the CO-OPS home page www.co-ops.nos.noaa.gov and were applied during acquisition. Verified smooth tides were applied post-processing.

Tides Zoning
Tidal zoning data, time and height corrections, was provided by NOAA CO-OPS (refer to *Appendix C*). The hydrographer applied final approved (smooth) tides to the survey data during processing. These verified tides were time and height corrected with the file W00019CORF.zdf that was provided by CO-OPS.

Statement of accuracy and compliance with HSSDM
The hydrographer believes that the zoning of tide correctors between the two primary tide stations is adequate for the purpose and location of the survey.

Assessment of sensors

Ancillary sensors
Sound velocity profiles were acquired using a SeaBird Electronics SeaCat SBE19 Conductivity, Temperature, and Depth (CTD) profiler (S/N 192472-0285). Raw conductivity, temperature, and pressure data were processed using Seabird Seaterm software. The software generated the SVP format profiles that were loaded for real-time corrections in the ISS2000 acquisition system. Casts were recorded to the full depth of the area profiled. Calibration reports and dates of the

two profilers are included in *Separate E.*

The speed of sound through the water was determined by a minimum of one cast every four hours during SWMB acquisition. In general the CTD casts showed the water column to be well mixed both spatially and temporally. Periodic comparisons between recent cast data were observed during the survey using Seabird Seaplot software. These observations showed a well-mixed water column both temporally and spatially.

The primary CTD was calibrated against a backup unit prior to the commencement of survey operations and at the completion of survey operations. Each unit had been calibrated prior to use during this survey. Calibration reports are included as Separate E.

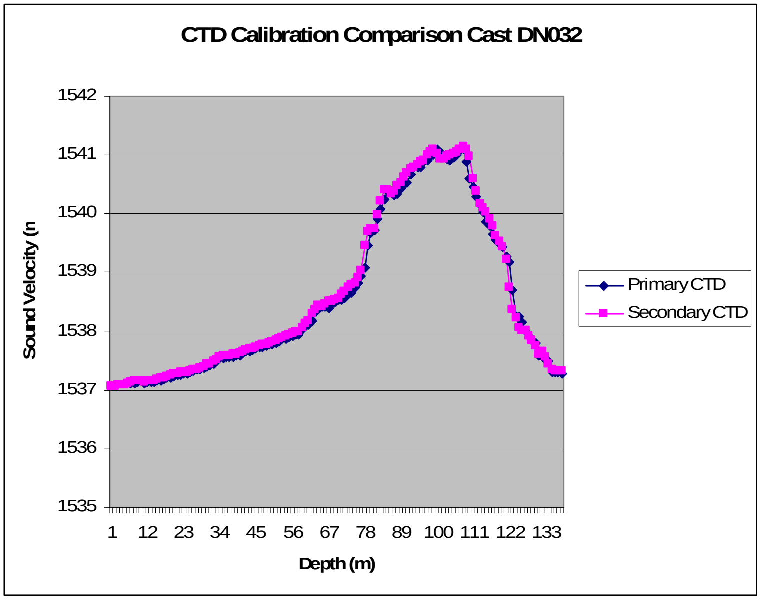


Figure 14. Comparison of the primary and back up CTD calibration cast

Assessment of Patch Test and Results

The Hydrographer believes that the interrogation of latency, pitch, roll, and gyro offsets in both a shallow water and deep water setting coupled with a thorough review of the patch test lines in Caris HIPS HDCS editor adequately meet the requirements for the patch test. The Hydrographer is confident in the values derived from the patch test for sensor alignment.

Assessment of Dynamic and Static Draft

Dynamic draft values for the Nancy Foster have not yet been determined. OCS personnel and the joint mapping team for the cruise agreed that until a set of values could be determined nothing would be applied. The application of a constant correction for dynamic draft was discussed for the reason that the Nancy Foster would survey at relatively constant 6 knots and a run-in would allow adequate time to reach said survey speed. Static draft (waterline) observations were attempted during each CTD cast. Corrections were determined for changes in vessel fuel loading and water discharge periodically during the survey. An initial static draft value will be used for acquisition and any subsequent changes will be applied post processing. Draft values ranged from 3.34m to 3.15m. The Lead Hydrographer feels that the corrections to static draft are adequate and that the basis for applying or not applying dynamic draft will be left for further review.

Assessment of Horizontal and Vertical offsets

Sensor Offsets

A survey crew from the National Geodetic Survey assisted the Benthic Habitat Mapping team by measuring offsets to the primary sensors with respect to the centerline of the Nancy Foster. Repeat measurements, from different stations, revealed that the determined positions for all of the various sensors, GPS antennas, and reference points are accurate to less than a decimeter. These values were entered into the POS/MV and ISS 2000 acquisition software. The offset values are additionally recorded as TPE offsets in the Caris Hydrographic Vessel File (HVF). A copy of this report is located in *Appendix B.*

Assessment of Sensor Calibrations

Each sensor associated with this survey underwent one form of calibration prior to commencement of survey operations. The multibeam sonar and offsets were calibrated with a bar check at 5 meters depth and a leadline while docked at the Molasses Pier in Port Alucroix. This data was digitally recorded to verify that proper offsets are being applied to the sonar. The positioning system was checked by recording positions obtained by the ships DGPS receiver and the POS/MV receiver simultaneously. The offsets to these systems were measured during the NGS survey. These measurements provide the baseline for comparing the two independent GPS. The positions checked to within 0.31 meters of the measured framework. The CTD was calibrated against the backup unit and both received calibrations by the manufacturer within the previous year. The final calibration for all systems including the motion sensor occurred during the patch test conducted on February 01, 2005. A second patch test occurred in deeper water and after the sonar was inspected on February 05, 2005. Based on these results the Lead Hydrographer feels that all systems are adequately calibrated for the purpose of this survey.

Assessment of Object Detection

Maximum sonar ping rates recorded by the acquisition software, moderate vessel speeds (less than 7 knots) in shallow water and adequate outer beam overlap (planned 10m) combine to meet object detection requirements that meet IHO Order 2 specifications in the benthic habitat sites and IHO Order 1 specifications in the NPS Inshore project area.

Bottom Coverage and Line Spacing

The survey lines are typically planned parallel to the general contours of the survey area. Line spacing was determined by depth using 10-meter overlap with 70° cutoff angles for the majority of the areas surveyed. The line spacing determined for the area designated NPS Inshore used a 60° cutoff angle. Reasonable attempts were made to collect holiday lines for the NPS Inshore area to ensure the least depth of a feature was surveyed. Preliminary review of the data by the Lead Hydrographer, determined that the bottom coverage and line spacing were considered adequate for the purposes of this survey. Post processing of the multibeam data revealed that several gaps in coverage exist. There are two prominent holidays in coverage in the charting demonstration site. The largest located at 18°18'15.53"N and 64°43'16.78"W was due to the presence of mooring buoys. The second gap located to the southeast is less prominent and proved to be a difficult pickup. A two-meter raster image of the corrected depths was used to determine coverage holidays in the demonstration site. This grid size was determined to exceed the parameters dictated in section 5.3.1 Demonstration of Coverage of the NOS Hydrographic Surveys Specifications and Deliverables where it states "Each colored cell in the raster image shall be binned, line by line, using shoal biased filtering at a bin size not to exceed 5 meters + 5 percent of the depth." Viewing a one-meter raster image of the coverage in the demonstration site reveals additional holidays. Maintaining the balance between demonstrating the charting capabilities of the cruise with completing the cruise mission resulted in these gaps. Additional holidays exist in the rest of the survey due to post-processing of bad sounding data. Attempts to fill in these holidays were not a priority.

Vessel speed

Survey operations were primarily conduced at a vessel speed of 6.0 knots. Speeds were reduced to 4.0-5.0 knots when survey lines extended beyond the shelf to depths that well exceeded 60 meters. Additionally, survey speeds were decreased when artifacts were observed during periods of heavy seas. The Lead Hydrographer considers the vessel speeds adequately ensonified the seafloor and were appropriate for the purposes of this survey.

Range scale and ping rate

The range scales reflected the depth and slope of the seafloor. Changes to the range scale were minimal. The accepted practice of keeping the relatively flat seabed in the "triangle" of the Reson acquisition window was maintained except where sideslope and extreme depths (greater than 100m) were observed. Multibeam data streamed to the acquisition system via an Ethernet port enabling the maximum ping rate to be collected. The range scale was the sole limitation to ping rate, with vessel speeds maintained to ensure 3.2 pings per 3 meters up to 30-meter depths. Neither ping rate nor range scale forced a deviation from the survey plan. The Hydrographer feels the parameters used for data acquisition adequately ensured the desired ensonification for this survey.

Assessment of Internal Accuracy

To assess the internal accuracy of the overall survey crosslines are compared to a reference surface of the area. The NOS Hydrographic Specifications and Deliverables document suggests a 5% target of crosslines to mainscheme. In the 2005 survey, 48.6 linear nautical miles of crosslines were collected. These lines represent 4.3% of the total main scheme lines collected.

The NPS Inshore habitat mapping/hydrographic charting demonstration site met the crossline requirements with 5.2% of the main scheme lines. The following table summarizes the mileage for the 2005 survey.

2005 US Virgin Islands Comprehensive Mileage Summary (Nmi)

Type	SRC05	BIC05	GRB05	GRM05	NPSI05	NPSO05	MSR05	Total 05
Mainscheme	13.9	78.0	78.0	186.2	454.7	77.2	237.3	1125.3
Crossline	0.0	0.0	2.3	9.7	23.9	8.5	4.2	48.6
% Crossline	0.0	0.0	3.0	5.2	5.2	11.0	1.8	4.3

Table 6.1

The Caris Hips Quality Control Report compares each available beam in the crossline to the reference surface. The report identifies the percent of those beams that fall within the 95% confidence level for depth accuracy in IHO classes Special Order, Order 1, and Order 2. These values are not to be confused with overall IHO order designation. It is worth noting that 73 of 101 beams analyzed for the demonstration site with this report met IHO Special Order depth accuracies.

Assessment of IHO Compliance

This overall assessment of the IHO standards is based on a model created by Rob Hare. The model takes into account the overall survey parameters used and physical oceanographic measurements for determining which level of IHO compliance the survey can potentially meet. The source for the error values used in the model were derived from manufacturer specifications, stated accuracies for tidal zoning, and vessel offset reporting (Appendix B). Based on the known vessel parameters and sensor RMS values, level of compliance was determined using the depths of 30 meters and 50 meters. The Vessel Configuration worksheets for the 30m and 50m spreadsheets are located in Appendix G. At the 30m depth, according to the model, 0 of 101 beams passed Special Order Accuracies and 45 of 101 met object detection specifications. 101 of 101 beams pass Order 1 accuracies and 72 of 101 beams pass object detect specifications. The same results were determined for Order 2 in both accuracy and object detection.

For the 50-meter depth, 0 of 101 beams met either accuracy or object detection specifics for IHO Special Order. 101 of 101 beams meet accuracy specifications for both Order 1 and Order 2 compliance. The Hydrographer is not certain why 7 beams more than the 30-meter depth model meet object detection specifications in both Order 1 and Order 2 compliance. In both cases 79 of 101 beams pass object detection specifications. The only parameter between the analysis in the two depth models that changed was the depth, noting that compliance improved for Order 1 and Order 2 as the depth increased and Special Order showed an overall degradation in the level of compliance, which would be expected.

VII. Submitted Data and Reports

The following documentation and data will accompany this survey upon completion:

<u>Data</u>

- Raw multibeam sonar sounding files in GSF format
- Processed multibeam sounding files in CARIS HDCS format
- Raw and processed sound velocity data files
- Predicted tides correctors (created from NOAA NWLON Gauges Charlotte Amalie (975-1639) and Lime Tree Bay (975-1401)
- Verified tide correctors created from NOAA NWLON Gauges Charlotte Amalie (975-1639) and Lime Tree Bay (975-1401)
- Tidal zoning prepared by NOAA CO-OPS
- XYZ files
- CARIS Hydrographic Vessel File (HVF)

<u>Documentation</u>

- Data Acquisition and Processing Report
- Cruise Instructions for cruise NF-05-05-USVI
- NGS POS/Sensor Components Spatial Relationship Survey Field Report
- CO-OPS Tides and Water Levels Report
- Patch Test Report
- Sensor Offset Documentation
- Copies of data acquisition and processing logs
- E-mail correspondence
- Digital photos

Approval Sheet (Separate Signed Document Verifying DAPR information)
APPROVAL

As Lead Hydrographer, I have ensured that standard field surveying and processing procedures were followed during this project in accordance with the Hydrographic Manual, Fourth Edition; Hydrographic Survey Guidelines; Field Procedures Manual, and the NOS Hydrographic Surveys Specifications and Deliverables Manual, as updated for 2003.

I acknowledge that all of the information contained in this report is complete and accurate to the best of my knowledge.

Approved and Forwarded: ______________________

John V. Lazar, Jr.
Lead Hydrographer

Appendix A. Cruise Instructions

Cruise Title: **Characterization of midwater seafloor habitats of the Buck Island Reef National Monument (BIRNM), St. Croix and the mid-shelf reef (MSR) of the Virgin Islands National Coral Reef Monument (VINCRM)**

Cruise Number NF-05-05-USVI

Period of Cruise:

DEP: 1/24/05 Ship transit to Frederiksted, St. Croix
ARR: 1/29/05 Ship arrive Frederiksted, St. Croix, USVI
DEP: 2/01/05 Begin seafloor mapping St. Croix, USVI
ARR: 2/12/05 Disembark at Charlotte Amalie, St. Thomas, USVI

Area of Operation: Buck Island National Monument and Salt River Bay National Historical Park and Ecological Preserve, St. Croix and Grammanik Bank, Mid-Shelf Reef, and Virgin Islands Coral Reef National Monument, St. Thomas and St. John

1.0 Scientific Objectives:

The Center for Coastal Monitoring and Assessment (CCMA) will be conducting the second year of an ongoing scientific research mission onboard the NOAA ship Nancy Foster. The purpose of the cruise will be to continue to collect swath bathymetry and acoustical backscatter data in six high priority areas within the USVI. Scientists will collect high resolution multibeam in mid-water depths approximately 15 to 300 meters so as to continue to characterize seafloor habitats within the USVI. The delineation and identification of seafloor habitats will be assisted by the use of a moderate depth Remotely Operated Vehicle (ROV). The vehicle has video and frame camera capability to depths of 300 meters and will be used to conduct transects within areas mapped in 2004 and 2005. This increased ROV capability in 2005 will enable us to characterize features identified in the 2004 multibeam acquisition, but were unable to previously video.

2.0 Schedule of Operations:

2.1 Daily Schedule:

See Table 1

30 January (Sunday):
Survey: Survey team installs remaining survey gear, does a gear shake-down of multibeam unit and survey planning.

31 January (Monday):
Survey: Survey team installs remaining survey gear, does a gear shake-down of multibeam unit and survey planning.
ROV: ROV team installs remaining survey gear, does a gear shake-down of ROV unit and video planning.
All: Press Briefing. Science party stays on board vessel at Fredriksted, St. Croix in the evening for early start 2/1.

1 February (Tuesday):

Transit/Patch Test: (0800-1100) Ship transit from Frederiksted to Patch Test area. Survey team conducts Patch Test to calibrate the Multibeam Echosounder (MBES) system in an area across the submerged eastern tip of St. Croix 4.0 NMI east of Buck Island. Ship safety briefing and scientific party mission briefing.
ROV: (1100-1300) ROV Buck Island.
Survey: (1300-1800) MBES Buck Island shallow depths.
ROV: (1800-2400) ROV Buck Island.

2 February (Wednesday):
ROV: (2400-0700) ROV Buck Island
Survey: (0700-1800) MBES Buck Island
Transit: (1800-2400) Ship transit from Buck island St. Croix to Grammanik Bank, St. Thomas.

3 February (Thursday):
Survey: (2400-0800) MBES Grammanik Bank.
ROV: (0800-1600) ROV Grammanik Bank.
Survey: (1600-2400) MBES Grammanik Bank.

4 February (Friday):
Survey: (2400-0800) MBES Grammanik Bank.
ROV: (0800-1600) ROV Grammanik Bank.
Survey: (1600-2400) MBES Grammanik Bank.

5 February (Saturday):
Survey: (2400-0800) MBES NPS_Inshore Monument.
ROV: (0800-1600) ROV NPS_Inshore Monument.
Survey: (1600-2400) MBES NPS_Inshore Monument.

6 February (Sunday):
Survey: (2400-0800) MBES NPS_Inshore Monument.
ROV: (0800-1600) ROV NPS_Inshore Monument.
Survey: (1600-2400) MBES NPS_Inshore Monument.

7 February (Monday):
Survey: (2400-0800) MBES NPS_Inshore Monument.
ROV: (0800-1600) ROV NPS_ Inshore Monument.
Survey: (1600-2400) MBES NPS_ Inshore Monument.

8 February (Tuesday):
Survey: (2400-0800) MBES NPS_Offshore Monument.
ROV: (0800-1600) ROV NPS_ Offshore Monument.
Survey: (1600-2400) MBES NPS_ Offshore Monument.

9 February (Wednesday):
Survey: (2400-0800) MBES NPS_ Offshore Monument.
ROV: (0800-1600) ROV NPS_ Offshore Monument.
Survey: (1600-2400) MBES NPS_ Offshore Monument

10 February (Thursday):
Survey: (2400-0800) MBES MSR.
ROV: (0800-1600) ROV MSR.
Survey: (1600-2400) MBES MSR.

11 February (Friday):
Survey: (2400-0800) MBES MSR.
ROV: (0800-1600) ROV MSR.
Survey: (1600-2400) MBES MSR.

12 February (Saturday):
Survey: (2400-0800) MBES MSR.
ROV: (0800-1400) ROV MSR. MBES break-down gear.
All: (1400-2400) Demobilization of gear from the NANCY FOSTER at Charlotte Amalie, St. Thomas.

2.2 Watches:

Vessel operations will typically be a ~ 24 hour workday. A "give and take" operation cycle will be instituted during these workdays via consultation between the Chief Scientist and Commanding Officer in order to balance crew complement with demands of day-night operations. One crew member will be required on deck to work the winch for the ROV and CTD casts.

In Science Party, the Field Party Chief is responsible for organization of operations and data, respectively.

3.0 Map of Operations:

(See Figure1 - 2 at end of text)

4.0 Description of Operations:

Multibeam Survey:

Survey Schedule/Personnel

A timeline has been developed for the installation and calibration of the sensors, as well as the data acquisition periods for surveying. A team from the Pacific Islands Fisheries Science Center (PIFSC) and a contract Lead Hydrographer will conduct the installation and calibration activities between the 12th and 23rd of January 2005 in the port of Charleston, S.C. A centerline survey will be conducted with the assistance of the National Geodetic Survey (NGS) office on the 14th and 15th of January. Preliminary calibrations and confidence checks will be conducted in Charleston. Final calibrations and confidence checks will occur on the 31st of January, 2005 in Port Alucroix, St. Croix. Survey operations will follow for 12 days as demobilization is scheduled for the 12th of February in Charlotte Amalie, St. Thomas.

Patch Test Survey Plan

A verifiable patch test is essential to a multibeam survey. The angle offsets of the sonar with respect to the motion sensor need to be accurately measured. An area across the submerged eastern tip of St. Croix four nautical miles east of Buck Island will provide the bathymetric features necessary to accurately assess the angle bias with the sonar head. Two predetermined lines (A&B) oriented North-South will be parallel and spaced apart to ensure abundant overlap of outer beams on adjacent lines. The lines will be surveyed in the following order and speeds.

Order	Line	Direction	Speed	Bias Measured
1	**A**	**S**	**L**	**R1a, P1a, P2a, Y1a, L1a**
2	**A**	**N**	**L**	**R1b, P1b, P2b, Y2a**
3	**B**	**S**	**L**	**R2a, P3a, P4a, Y1b**
4	**B**	**N**	**L**	**R2b, P3b, P4b, Y2b L2a**
5	**A**	**S**	**H**	**L1b**
6	**B**	**N**	**H**	**L2b**

Ample time between passes on the same line will be given to ensure ship propeller disturbances have cleared and will not impact data quality. Additional lines can be included adjacent to planned lines and this schedule can be modified. Data from the patch test will be processed to the satisfaction of the Lead Hydrographer.

Data Acquisition Methodology
Six priority survey regions have been identified for benthic habitat mapping during this cruise and are shown in Figures 1 and 2. While the protocols for collecting high quality data do not change from one survey area to the next, one site, the National Park Service (NPS) Inshore in Figure 2, has been identified as a high priority for charting updates. Therefore the mapping team has developed survey protocols that attempt to find a common ground that permits the Office of Coast Survey (OCS) to use the data without sacrificing benthic habitat mapping objectives. The additional efforts to ensure charting quality data are identified below.

Within the NPS Inshore project area a 120° swath of data will be accepted while using the additional 15° to both sides strictly for reconnaissance. Line spacing will be planned such that full bottom coverage is obtained using the limited swath within the 60°filter. Cross checklines that meet the 5% of linear survey nautical miles criteria will be observed. Dangers to Navigation (DTONs) will be reported if located and an additional line focusing nadir beams over the object will be recorded. Any additional measures to identify and image the least depth will be used at the discretion of the Chief Scientist. For the other five survey areas, all soundings within a 140° swath will be accepted. Soundings outside of the 70° filter will be flagged as reconnaissance beams. A minimum of one cross checkline will be recorded in each area. Sound velocity casts will be recorded at the start of each 8 hour watch and every 4 hours after. Survey speeds will be maintained that meet object detection standards specified in Section 5.2.2 of NOS Hydrographic Surveys Specifications and Deliverables. The Center for Operational Oceanographic Products and Services (CO-OPS) tide zoning will be applied real-time with predicted tides. CO-OPS smooth tides will be applied in post processing. A real-time coverage plot of attitude corrected data with the appropriate angle filters will be recorded.

The Salt River Canyon slope will be surveyed to ensure that minimum overlap is accomplished with those beams upslope of nadir due to incidence angles associated with a steep slope. The full acceptable swath will be used as soon as the ship is inshore of the bank/shelf escarpment. The Buck Island Reef Channel will be surveyed with the shoal channel depths controlling the line spacing. These areas will most likely require daylight operations due to the shoal depths and proximity to shoreline hazards. The Grammanik Bank area, the Mid Shelf Reef areas, and the National Park Service (NPS) Offshore area will be surveyed with similar line spacing used during the 2004 survey. An initial line plan for each survey area will be built with 5 meter spacing to allow the Hydrographer to track the changes to line spacing and respond to the changing depths. A general guide for line spacing follows.

70°	Line Spacing		
Depths (m)	**Available Swath (m)**	**Overlap Constant (m)**	**Max Spacing (m)**
10	54.9	10	44.9
15	82.4	10	72.4
20	109.9	10	99.9
25	137.4	10	127.4
30	164.8	10	154.8

60°	Line Spacing		
Depths (m)	**Available Swath (m)**	**Overlap Constant (m)**	**Max Spacing (m)**
10	34.6	10	24.6
15	52.0	10	42.0
20	69.3	10	59.3
25	86.6	10	76.6
30	103.9	10	93.9

The line plan for the nearshore survey area of the NPS boundary will take into account ship maneuverability and proximity to shore hazards. Data collected offline and during turns will be edited from the final dataset in all areas.

Data Quality Assurance/Quality Control Methodology

System confidence checks prior to the commencement of multibeam operations will be conducted. A position check that validates the navigational accuracies will be conducted between two independent DGPS receivers during mobilization of the Nancy Foster in Charleston and prior to survey operations in the USVI. A barcheck comparison to digital depth records will be conducted prior to survey operations in the USVI to verify the correct application of sonar offsets. CTD calibrations will be conducted with the primary SBE-19P unit and the backup SPE-19 belonging to the ship.

A crossline comparison will be observed to identify problems with tidal modeling. Confidence in beam quality will be demonstrated through the comparison. Sun-illuminated imagery of the data will be used for detection of artifacts and quality verification. Additional analysis will be conducted through OCS.

Video mapping: ROV operations will be conducted at each of the six 2005 survey areas as well as visits to the areas surveyed in 2004 by CCMA onboard the Nancy Foster. The University of North Carolina at Wilmington National Undersea Research Program (NURP) office will be providing three ROV operators and the full complement of equipment necessary to utilize the Spectrum Phantom 2. The ROV transects will primarily be conducted while the ship is drifting. Preliminary transect lines will be provided to the ship prior to the commencement of the cruise.

5.0 Requirements and Equipment:

5.1 Vessel Provided:

1) Hand held radios for communication between launches, NANCY FOSTER, and deck.
2) CCMA Steel Multibeam Mounting Pole
3) CTD 1000 m depth rating.

5.2 Program Provided:

	Equipment	Leg
1)	Underwater video + camera equipment + tow bodies (Phantom 2 ROV) (NURP).	Charleston
2)	3 USB 250GB Maxtor 5000XT harddrives (CCMA).	Charleston
3)	Five high end laptops and two flat screen monitors.	Charleston
4)	HYPACK, CARIS, MapInfo, ArcGIS, and VelociWin.	Charleston
5)	Reson 8101 ER MB system, POS/MV, Saber, ISS2000 and DGPS (NMFS).	Charleston

6.0 Scientific Personnel:

6.1 Chief Scientist Authority

The Chief Scientist has the authority to revise or alter the technical portions of the instructions provided that, after consultation with the Commanding Officer, it is ascertained that the proposed changes will not: 1) jeopardize the safety of the personnel on the ship, 2) exceed the time allotted for the project, 3) result in undue additional expense, or 4) alter the general intent of the Project Instruction.

6.2 Scientific Personnel List:

Chief Scientist: Tim Battista
Lead Hydrographer: Jay Lazar
ROV: Matt Kendall

Male:	Organization	ROV	Multibeam	Legs
Tim Battista	NOAA		X	STC/STJ
Jay Lazar	Contractor		X	STC/STJ
Scott Ferguson	NOAA		X	STC/STJ
Matt Kendall	NOAA	X		STC/STJ
Charles Menza	NOAA	X		STC/STJ
Jason Vasques	USVI	X		STC/STJ
Lance Horn	UNCW NURP	X		STC/STJ
Glen Taylor	UNCW NURP	X		STC/STJ
Jeffrey Williams	UNCW NURP	X		STC/STJ

Female		ROV	Multibeam	Legs
Joyce Miller	NOAA		X	STC/STJ
Ada Otter	NOAA		X	STC/STJ
Zandy Hills-Starr	NPS	X		STC
Paige Rothenberger	USVI	X		STJ
Susanna Holst	NOAA		X	STC/STJ

TASK TEAMS

ROV

1) **Menza**, Horn, Williams, and Vasques
2) **Kendall,** Taylor, Hills-Starr/Rothenberger

MULTIBEAM

1) **Lazar**, Battista, Holst
2) **Miller**, Ferguson, Otter

Person in **bold** is field party chief – responsible for prepping rest of team

Identification: All scientific personnel planning to board the ship should have in their possession at the time of boarding, a proper photo identification card (agency ID, drivers license, etc.).

6.4 History Reports:
Upon acceptance of this proposal, and receipt by the Chief Scientist of the forms, the Chief Scientist will forward completed copies of the NOAA Health Services Questionnaire for all embarking scientific personnel to the Commanding Officer for review at lease 7 days in advance of the cruise.

7.0 Miscellaneous Activities:
None known at this time.

7.1 Bridge Activities:
It is requested that a copy of the ship's *Deck Log - Weather Observation Sheet NOAA 77-13d* for and digital SCS data for the entire cruise be provided to the Chief Scientist upon departure of the science party or transmitted within 2 weeks thereafter.

8.0 Modification of Cruise Instructions:
Additional operations and ancillary projects, not covered under the main project, may be performed on a "not to interfere" basis. The Chief Scientist is responsible for determining the priority of the additional work, provided that any changes are discussed with the Commanding Officer and do not constitute a risk to the safety of the ship or personnel and do not significantly change the schedule for this cruise. If the requirements for the additional work place significantly different requirements on the ship, amendments to the Cruise Instructions must be prepared and approved.

9.0 Ancillary Tasks:
Ship's personnel conduct ancillary tasks. Instructions for ancillary tasks routinely assigned to Marine Operations Center ships are contained in *Marine Operations Center Directive 1803.00, Ancillary Tasks for NOAA Vessels*.

10.0 Hazardous Materials:
An inventory list and a *Material Safety Data Sheet* for each hazardous material will accompany hazardous material brought on board NANCY FOSTER by scientific parties. This information should be provided to the Commanding Officer. On departure from the ship, scientific parties will provide an inventory of hazardous material to the Commanding Officer showing that all hazardous material brought on board have been properly used up or removed in suitable waste containers. No anticipated hazardous materials is anticipated to be brought onboard.

The *Material Safety Data Sheet* is normally available from the manufacturer of the hazardous product. Procedures followed for use of chemicals will be those outlined in the *Chemical Hygiene Plan for Chemical Labs* aboard NOAA ships. The Science Party will provide a small spill containment kit appropriate for these chemicals.

11.0 Navigation:
Survey and ROV operations will be operated using DGPS. Navigation information via Hypack software will be fed to the Bridge monitor from the Wet and Dry labs via cable.

12.0 Communications:
A progress report on operations prepared by the Chief Scientist may be relayed to the program office. Sometimes it is necessary for the Chief Scientist to communicate with another vessel, aircraft, or shore facility. Through various modes of communication, the ship is able to maintain contact with the Marine Operations Center on an as needed basis. These methods will be made available to the Chief Scientist upon request, in order to conduct official business. Due to a new directive from Marine Operations Center, the ship must charge the science party for all calls made on the cell or sky-cell telephone. INMARSAT, Sky Cell and cellular communication costs shall be reimbursed to the ship for telephone calls made by all scientific personnel. Currently, Sky Cell and cellular telephone services are about $0.89 per minute and INMARSAT Mini-M is around $1.68 per minute for voice. These charges will be assessed against the program after NANCY FOSTER receives the bill. There is generally a three-month delay receiving the bill for review. The Chief Scientist will be required to keep a log of all calls made by the science party. The program will also provide a cell phone to be kept on the bridge.

13.0 Disposition of Data:
The Chief Scientist is responsible for the disposition of data.

14.0 Reports:
The requirement for a formal cruise report by the Chief Scientist is left to the discretion of the CCMA Center Director. A Ship Operations Evaluation Form is to be completed by the Chief Scientist(s) and forwarded to:

Office of Marine and Aviation Operations
Program Services and Outsourcing Division
SSMC3, Room 12872
1315 East-West Highway
Silver Spring, MD 20910-3282

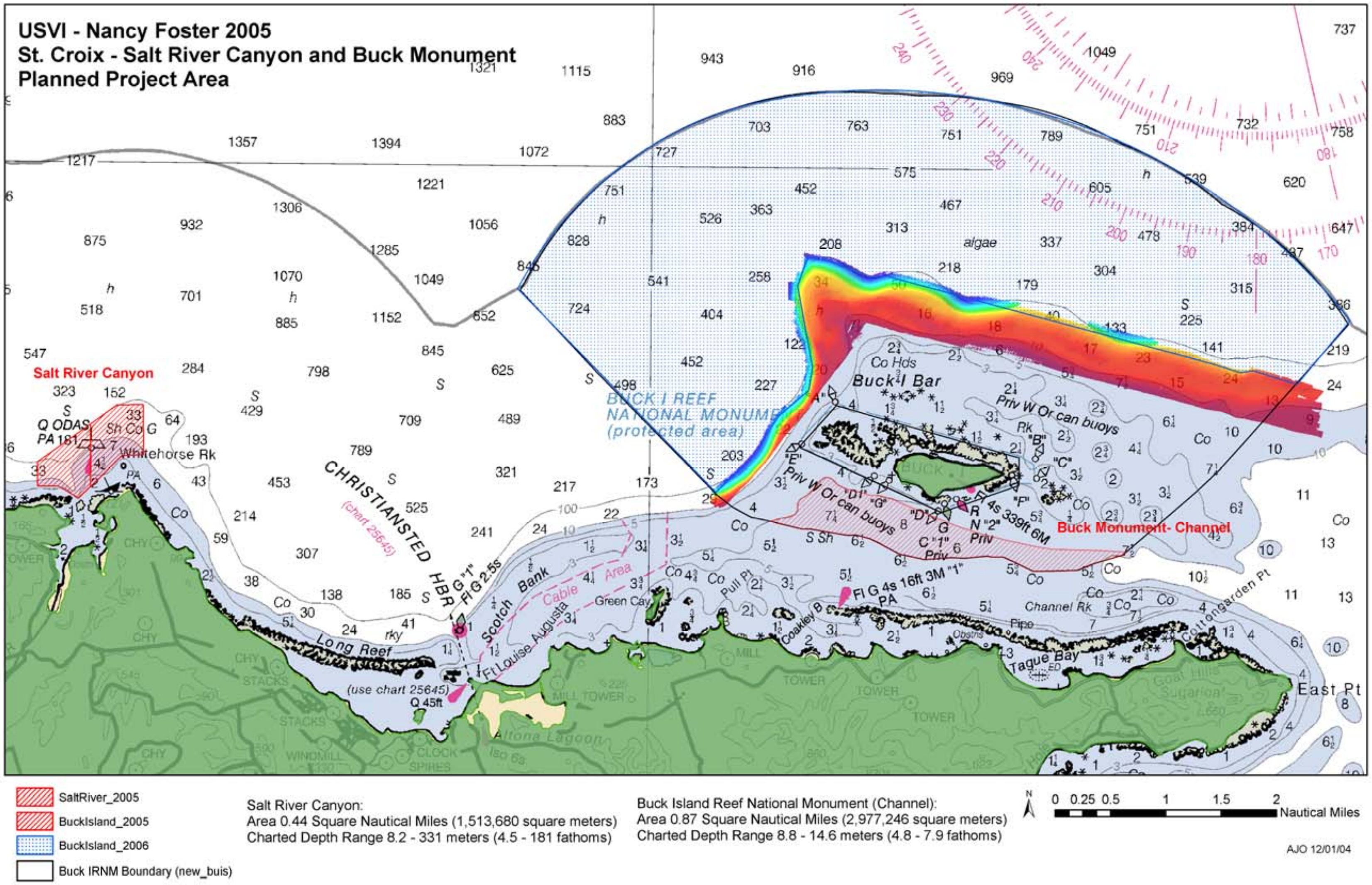
15.0 Cruise Instruction Approvals:

The Marine Operations Center and NANCY FOSTER will acknowledge receipt of these instructions.

Table 1. Mission operation schedule.

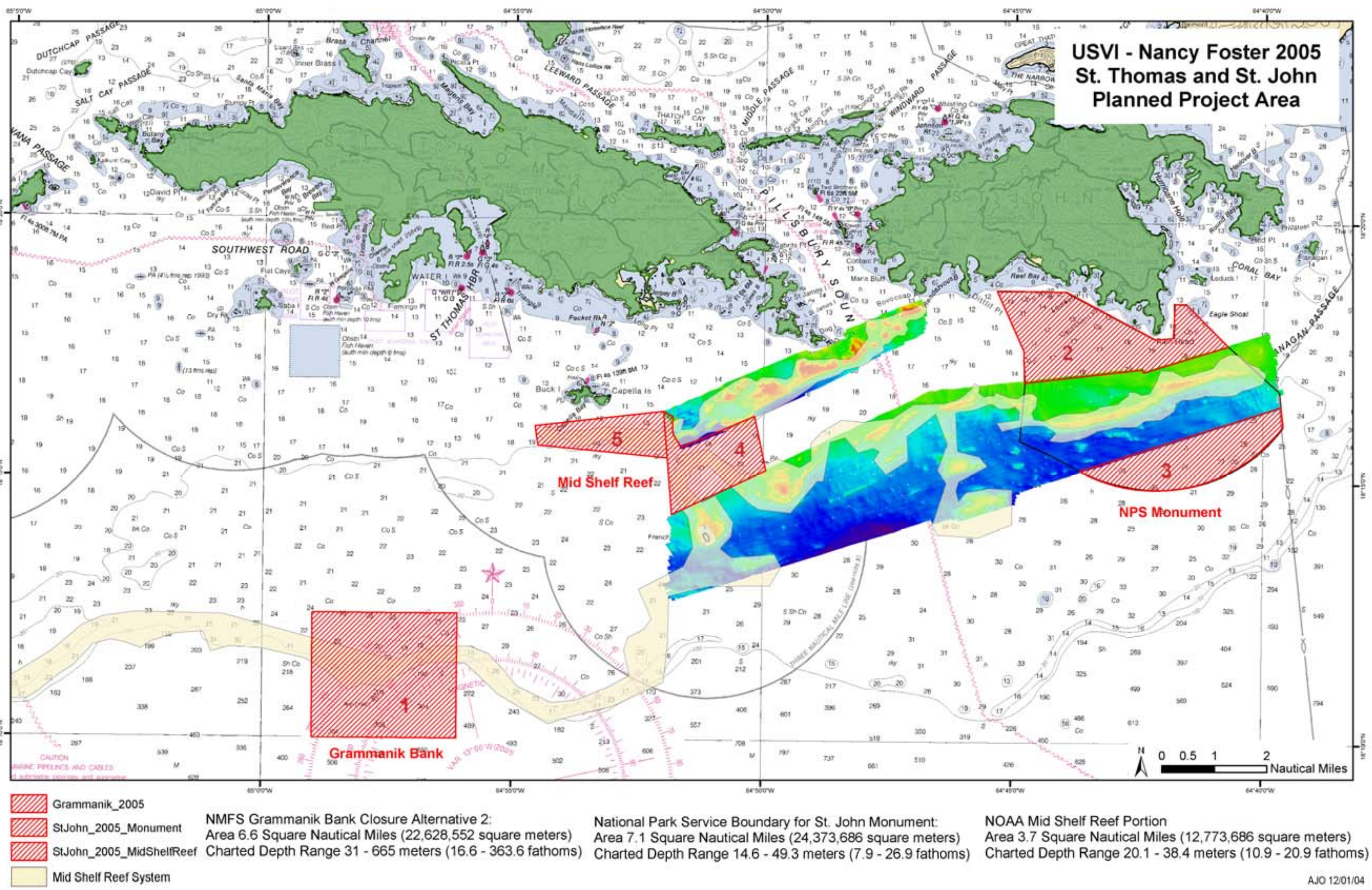
DAY	DATE	LOCATION	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Sun	30-Jan	STX	MOBILIZATION/TRAINING/PRESS																							
Mon	31-Jan	STX																								
Tue	1-Feb	STX	OFF DUTY								Transit/ Patch Test			ROV Buck/Calibrate MBES		Multibeam Buck: All						ROV Buck				
Wed	2-Feb	STX	ROV Buck							Multibeam Buck/Salt River												TRANSIT TO STJ				
Thu	3-Feb	STJ/STT	Multibeam Grammanik Bank								ROV Grammanik Bank								Multibeam Grammanik Bank							
Fri	4-Feb	STJ/STT	Multibeam Grammanik Bank								ROV Grammanik Bank								Multibeam Grammanik Bank							
Sat	5-Feb	STJ/STT	Multibeam NPS_A Monument								ROV NPS_A Monument								Multibeam NPS_A Monument							
Sun	6-Feb	STJ/STT	Multibeam NPS_A Monument								ROV NPS_A Monument								Multibeam NPS_A Monument							
Mon	7-Feb	STJ/STT	Multibeam NPS_A Monument								ROV NPS_A Monument								Multibeam NPS_A Monument							
Tue	8-Feb	STJ/STT	Multibeam NPS_B Monument								ROV NPS_B Monument								Multibeam NPS_B Monument							
Wed	9-Feb	STJ/STT	Multibeam NPS_B Monument								ROV NPS_B Monument								Multibeam NPS_B Monument							
Thu	10-Feb	STJ/STT	Multibeam MSR								ROV MSR								Multibeam MSR							
Fri	11-Feb	STJ/STT	Multibeam MSR								ROV MSR								Multibeam MSR							
Sat	12-Feb	STJ/STT	Multibeam MSR								ROV MSR						DEMOBILIZATION									
Sun	13-Feb	STT	DEMOBILIZATION																							

Figure 1. Salt River Canyon and Buck Island Monument survey areas around St. Croix.



USVI - Nancy Foster 2005
St. Croix - Salt River Canyon and Buck Monument
Planned Project Area
Salt River Canyon
BUCK I REEF
NATIONAL MONUMENT
(protected area)
Buck I Bar
Buck Monument- Channel
CHRISTIANSTED HBR
(chart 25645)
(use chart 25645)
Scotch Bank
Long Reef
Whitehorse Rk
Green Cay
Tague Bay
Cottongarden Pt
East Pt
Altona Lagoon
Ft Louise Augusta
Cable Area
SaltRiver_2005
BuckIsland_2005
BuckIsland_2006
Buck IRNM Boundary (new_buis)
Salt River Canyon:
Area 0.44 Square Nautical Miles (1,513,680 square meters)
Charted Depth Range 8.2 - 331 meters (4.5 - 181 fathoms)
Buck Island Reef National Monument (Channel):
Area 0.87 Square Nautical Miles (2,977,246 square meters)
Charted Depth Range 8.8 - 14.6 meters (4.8 - 7.9 fathoms)
0 0.25 0.5 1 1.5 2
Nautical Miles
AJO 12/01/04

Figure 2. Grammanik Bank, Mid Shelf Reef, and NPS Monuments A and B survey areas around St. John and St. Thomas.


USVI - Nancy Foster 2005
St. Thomas and St. John
Planned Project Area
Mid Shelf Reef
NPS Monument
Grammanik Bank
1
2
3
4
5
SOUTHWEST ROAD
DUTCHCAP PASSAGE
SALT CAY PASSAGE
LEEWARD PASSAGE
MIDDLE PASSAGE
WINDWARD PASSAGE
PILLSBURY SOUND
CORAL BAY
ST THOMAS HBR
0 0.5 1 2 Nautical Miles
Grammanik_2005
StJohn_2005_Monument
StJohn_2005_MidShelfReef
Mid Shelf Reef System
NMFS Grammanik Bank Closure Alternative 2:
Area 6.6 Square Nautical Miles (22,628,552 square meters)
Charted Depth Range 31 - 665 meters (16.6 - 363.6 fathoms)
National Park Service Boundary for St. John Monument:
Area 7.1 Square Nautical Miles (24,373,686 square meters)
Charted Depth Range 14.6 - 49.3 meters (7.9 - 26.9 fathoms)
NOAA Mid Shelf Reef Portion
Area 3.7 Square Nautical Miles (12,773,686 square meters)
Charted Depth Range 20.1 - 38.4 meters (10.9 - 20.9 fathoms)
AJO 12/01/04

Submitted by:

Dr. Russell Callender
Center Director,
Center for Coastal Monitoring
and Assessment

Date___________________________

Mr. Timothy A. Battista
Biogeographic Team,
Center for Coastal Monitoring
and Assessment

Date___________________________

Approved by:

Captain Gary Bulmer, NOAA
Commanding Officer, Marine Operations Center Atlantic

Date___________________________

Appendix B. Centerline Survey

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Ocean Service
National Geodetic Survey
Geodetic Services Division
Instrumentation & Methodologies Branch

NOAA Ship- Nancy Foster
POS/Sensor Components Spatial Relationship Survey
Field Report

Kendall Fancher
January , 2004

NOAA Ship - Nancy Foster
Centerline Survey

PURPOSE

The primary purpose of the survey was to accurately determine the spatial relationship of various navigation and survey instrumentation sensor components located onboard the NOAA ship Nancy Foster. Additionally, Reference Points were established onboard the vessel to aid in the spatial determination of those survey instrumentation components not yet installed.

PROJECT DETAILS

This survey was conducted on the 13th, 14th, and 15th of January at the Old Naval Shipyard in Charlston, South Carolina while the ship was docked. The weather on the 13th was partly sunny and mild with intermittent showers. The weather on the 14th was cool with light to moderate rain throughout the morning and intermittently during the afternoon. The weather on the 15th was windy and cold. Reconnaissance was conducted on the 14th, with the aid of Jay Lazar, Ada Otter, and Scott Ferguson, to determine exactly where each control point was to be established for each sensor and where the Reference Points were to be established. Data collection was conducted on the 14th and 15th.

INSTRUMENTATION

The Leica (Wild) TC2002 precision total station was used to make all measurements.

Technical Data

Angle Measurement

Resolution 0.03 seconds

Smallest unit in display 0.1 seconds

Standard Deviation

Horizontal angle 0.5 seconds

Vertical angle 0.5 seconds

Distance Measurement 1mm + 1ppm

A standard “peanut” prism was used as a sighting target and for distance measurement during this project. This has an offset of 30 mm. Prism offset was accounted for during data collection.

PERSONNEL

Kendall Fancher NOAA/NOS/NGS/GSD/I&M Branch
(540) 373-1243
Roy Anderson NOAA/NOS/NGS/SRD/Project Development Branch
(301) 713-3194
Jim Harrington NOAA/NOS/NGS/GSD/Geodetic Advisors Group

NOAA Ship Nancy Foster
Centerline Survey

SURVEY PROCEDURES

Establishing the Centerline

Two marks (CENTERLINE POINT 1 and CENTERLINE POINT 2) were recovered on the centerline of the main deck. Diagrams for the ship indicated that these control marks were on the centerline of the vessel. Both marks consisted of a circular metal disk with a center hole serving as the datum point. Jay Lazar requested that CENTERLINE POINT 1 serve as the primary control point. The following coordinates were assumed for CENTERLINE POINT 1; easting of 1000.000m, northing of 1000.000m, and up of 1000.000m. While occupying CENTERLINE POINT 1, a distance measurement was taken to CENTERLINE POINT 2 and a height difference was determined. Given the distance measured along the centerline of the ship and with the height difference established between the two points, the following coordinates were determined for CENTERLINE POINT 2; easting of 1000.000m, northing of 987.203m, and up of 999.847.

Establishing ROV REFERENCE POINT, TEMPORARY POINT 2, MULTIBEAM REFERENCE POINT 1, AND MULTIBEAM REFERENCE POINT 2

A punch mark was set in the top of a housing pipe, on top of and in line with the center of the deck rail, for the ROV deployment housing to serve as ROV REFERENCE POINT. A random point on the main deck was set for TEMPORARY POINT 2. A punch mark was set in the top center of the deck rail, directly above the center of the multibeam sensor deployment housing pipe, to serve as MULTIBEAM REFERENCE POINT 1. A punch mark was set in the top center of the deck rail, about 0.4 m towards the back of the ship from MULTIBEAM REFERENCE POINT 1, to serve as MULTIBEAM REFERENCE POINT 2. While occupying CENTERLINE POINT 1, a 180 bearing was input into the instrument and CENTERLINE POINT 2 was used for initialization. After initialization was conducted, angular measurements and distances were taken to establish ROV REFERENCE POINT, TEMPORARY POINT 2, MULTIBEAM REFERENCE

POINT 1, AND MULTIBEAM REFERENCE POINT 2 . After establishing coordinates for these control points, angular measurements and distances were taken to determine an azimuth check. The azimuth check revealed a closure of 0.001m in the easting, 0.000m in the northing, and 0.000m in the up component.

Establishing ROV GPS ANTENNA, GPS ANTENNA PORT SIDE, GPS ANTENNA STARBOARD SIDE, IMU GPS REFERENCE POINT PORT SIDE, and IMU GPS REFERENCE POINT STARBOARD SIDE

Three GPS antennas (ROV GPS ANTENNA, GPS ANTENNA PORT SIDE, and GPS ANTENNA STARBOARD SIDE) were positioned, relative to CENTERLINE POINT 1, this survey. All three of these antennas were manufactured by Northstar, part number AT7530. A point at the top center of each antenna was selected for positioning. The distance from the top center of the antenna to the ARP for this model of antenna was measured to be 0.060 M. The position can be corrected to the electrical phase center of

The antenna by deducting 0.060 M from the determined up component for each antenna, then applying the electrical phase center constant to the determined component for each antenna. A punch mark was set in top of and 0.06 m from the rear port side corner of a metal vent on the 02 deck to serve as IMU GPS REFERENCE POINT PORT SIDE. A punch mark was set in top of and 0.06 m from the rear starboard side corner of a metal vent on the 02 deck to serve as IMU GPS REFERENCE POINT STARBOARD SIDE. While occupying CENTERLINE POINT 2, a zero bearing was input into the instrument and CENTERLINE POINT 1 was used for initialization. After initialization was conducted, angular measurements and distances were taken to establish ROV GPS ANTENNA, GPS ANTENNA PORT SIDE, GPS ANTENNA STARBOARD SIDE, TEMPORARY POINT 1, IMU GPS REFERENCE POINT PORT SIDE, and IMU GPS REFERENCE POINT STARBOARD SIDE. After establishing coordinates for these antennas, angular measurements and distances were taken to determine an azimuth check. The azimuth check revealed a closure of 0.001m in the easting, 0.000m in the northing, and 0.000m in the up component.

Establishing TEMPORARY POINT 1

TEMPORARY POINT 1 was positioned, relative to CENTERLINE POINT 1, this survey. A punch mark was set in the center of the metal threshold for an access door leading to the forward science lab to serve as TEMPORARY POINT 1. While occupying TEMPORARY POINT 2, an internally stored bearing for CENTERLINE POINT 2 was used for initialization. After initialization was conducted, angular measurements and distances were taken to establish TEMPORARY POINT 1. Additionally, angular measurements and distance were taken to check the previously determined positions of the following; ROV GPS ANTENNA, GPS ANTENNA PORT SIDE, IMU GPS REFERENCE POINT PORT SIDE, IMU GPS REFERENCE POINT STARBOARD SIDE, ROV REFERENCE POINT, MULTIBEAM REFERENCE POINT 1, and MULTIBEAM REFERENCE POINT 2. After establishing coordinates for TEMPORARY POINT, angular measurements and distances were taken to determine an azimuth check. The azimuth check revealed a closure of 0.000m in the easting, 0.000m in the northing, and 0.002m in the up component.

Establishing the IMU

The IMU was positioned, relative to CENTERLINE POINT 1, this survey. The center of a target located on the top center of the IMU served as the IMU control point. While occupying TEMPORARY POINT1, an internally stored bearing for CENTERLINE POINT 2 was used for initialization. After initialization was conducted, angular measurements and distances were taken to establish TEMPORARY POINT 1. After establishing coordinates for the IMU, angular measurements and distances were taken to determine an azimuth check. The azimuth check revealed a closure of 0.002m in the easting, 0.000m in the northing, and 0.025m in the up component.

NOAA Ship Nancy Foster
Centerline Survey

Discussion

The coordinate system used for this survey can be described in the following manner; The northing runs along the centerline of the ship and is positive from CENTERLINE POINT 1 forward to the bow of the ship, the easting is perpendicular to the northing and is positive to the right of CENTERLINE POINT 1 when viewed from the back of the ship, the up component is positive when above the level of CENTERLINE POINT 1.

Repeat measurements, from different stations, revealed that the determined positions for all of the various sensors, gps antennas, and reference points are accurate to less than a decimeter. The exceptions are IMU and TEMPORARY POINT 1. These two points are accurate to less than 3 centimeters.

Degraded observations where encountered when measuring inside of the ship from the main deck. The change in ambient temperature between outdoors and inside of the ship was suspected culprit. For future such surveys a point should be determined in the doorway leading to the outdoors, rather than attempting to measure very far inside of the ship, to minimize this effect.

NOAA Ship Nancy Foster
Centerline Survey

		OBSERVED			COORDINATES		
ID	**NAME**	**EASTING**	**NORTHING**	**UP**	**EASTING**	**NORTHING**	**UP**
CL01	CENTERLINE POINT 1	1000.000	1000.000	1000.000	0.000	0.000	0.000
CL02	CENTERLINE POINT 2	1000.000	987.203	999.847	0.000	-12.797	-0.153
TP01	TEMPORAY POINT 1	1003.514	1012.814	1000.407	3.514	12.814	0.407
MB01	MULTIBEAM REFERENCE POINT 1	1005.943	996.711	1001.020	5.943	-3.289	1.020
MB02	MULTIBEAM REFERENCE POINT 2	1005.944	996.405	1001.016	5.944	-3.595	1.016
ROV1	ROV REFERENCE POINT	994.073	1000.147	1001.155	-5.927	0.147	1.155
ROVG	ROV GPS ANTENNA	999.866	1002.380	1003.795	-0.134	2.380	3.795
IMS	IMU GPS REFERENCE POINT STARBOARD SIDE	995.979	1012.779	1006.804	-4.021	12.779	6.804
IMP	IMU GPS REFERENCE POINT PORT SIDE	994.357	1012.779	1006.801	-5.643	12.779	6.801
GPP	GPS ANTENNA PORT SIDE	996.991	1024.186	1012.032	-3.009	24.186	12.032
GPS	GPS ANTENNA STARBOARD SIDE	1003.050	1024.308	1012.320	3.050	24.308	12.320
IMU	IMU	1001.115	1017.883	1000.642	1.115	17.883	0.642

Appendix C. Tides Report

STATEMENT OF WORK
NF-05-05-USVI, Virgin Islands
(12/20/2005 MMC)

1.0. TIDES AND WATER LEVELS

1.1. Specifications

Tidal data acquisition, data processing, tidal datum computation and final tidal zoning shall be performed utilizing sound engineering and oceanographic practices as specified in National Ocean Service (NOS) Hydrographic Surveys Specifications and Deliverables (March 2003).

1.2. Vertical Datums

The tidal datums for this project are Chart Datum, Mean Lower Low Water (MLLW) and Mean High Water (MHW). Soundings are referenced to MLLW and heights of overhead obstructions (bridges and cables) are referenced to MHW.

1.2.1. The operating National Water Level Observation Network (NWLON) stations at San Juan, PR (9755371), Charlotte Amalie, St.Thomas (9751639), and Lime Tree Bay, St. Croix (9751401) will serve as datum control for this project. Therefore, it is critical that these stations remain in operation during all periods of hydrography.

The contractor and the Center for Operational Oceanographic Products and Services (CO-OPS) are jointly responsible for ensuring that valid water level data are collected during periods of hydrography. The contractor is required to monitor the pertinent water level data via the CO-OPS Web site at http://co-ops.nos.noaa.gov/hydro.shtml or through regular communications with the COTR or the COTR's CO-OPS authorized representative (Tom Landon) at 301-713-2897 x191 or via e-mail: Tom Landon@noaa.gov) before and during operations. The COTR or the COTR=s CO-OPS authorized representative (Tom Landon) will serve as liaison between the contractor and NOS/CO-OPS (CO-OPS) to confirm operation of this station and to ensure the acquisition of valid water level data during periods of hydrography. Problems or concerns regarding the acquisition of valid water level data identified by the contractor shall be communicated with the COTR or the COTR=s CO-OPS authorized representative (Tom Landon) to coordinate the appropriate course of action to be taken such as gauge repair and/or developing contingency plans for hydrographic survey operations.

1.3. Tide Reducer Stations

1.3.1. The operating water level stations at San Juan, PR (9755371), Charlotte Amalie, St.Thomas (9751639), and Lime Tree Bay, St. Croix (9751401) must be in operation during all periods of hydrography. See Section 1.2.1. for responsibilities.

No subordinate water level stations are required for this project, however, supplemental and/or back-up water level stations may be necessary depending on the complexity of the hydrodynamics and/or the severity of the environmental conditions of the project area. The installation and continuous operation of water level measurement systems (tide gauges) at subordinate station locations is left to the discretion of the contractor, subject to the approval of the COTR. If the contractor decides to install additional water level stations, then a 30-day minimum of continuous data acquisition is required. For all subordinate stations, data must be collected throughout the entire survey period for which they are applicable, and not less than 30 continuous days. This is necessary to facilitate the computation of an accurate datum reference as per NOS standards.

1.3.2 Tidal Records: If subordinate water level stations are installed, submit water level data, such as leveling records, field reports, and any other relevant data/reports, including the data downloaded onto diskette/CD within 1 week after the end of each month or the end of hydrography to CO-OPS/RDD. Refer to Section 1.1.

1.3.2.1. Tidal records should be forwarded to the following address:

NOAA/National Ocean Service/CO-OPS
Chief, Requirements and Development Division
N/OPS1 - SSMC4, Station 6531
1305 East-West Highway
Silver Spring, MD 20910

1.3.3. If subordinate water level stations are installed, recover all historical bench marks at each subordinate water level station. If any bench marks are destroyed or not found, install new bench marks to replace them. In the event of a new station with no historical marks, installation of a minimum of five bench marks will be required. Third-order levels from the tide staff or sensor to a minimum of five bench marks (including the primary bench mark) are required at the beginning and end of the survey period. See Section 1.1. for clarification of requirements.

1.4. Zoning

1.4.1. The water level stations at San Juan, PR (9755371), Charlotte Amalie, St.Thomas (9751639), and Lime Tree Bay, St. Croix (9751401) are the reference stations for predicted tides for hydrography near the Virgin Islands. The time and height correctors listed below for applicable zones should be applied to the predicted tides at the station indicated during the acquisition and preliminary processing phases of this project. Predictions may be retrieved in one month increments over the Internet from the CO-OPS Home Page at http://www.co-ops.nos.noaa.gov/ and then clicking on APredictions.@ The contractor must notify the COTR or the COTR's authorized representative immediately of any problems concerning the predicted tides. Predictions are six-minute time series data relative to MLLW in metric units on Greenwich Mean Time. For the time corrections, a negative (-) time correction indicates that the time of tide in that zone is earlier than (before) the predicted tides at the reference station. A positive (+) time correction indicates that the time of tide in that zone is later than (after) the predicted tides at the reference station. For height corrections, the water level heights relative to MLLW at the reference station are multiplied by the range ratio to estimate the water level heights relative to MLLW in the applicable zone.

Zone	Time Corrector(mins)	Range Ratio	Predicted Reference Station

VIR2				0	1.01
			9751639		
VIR11				0	1.01
			9751639		
VIR12				+6	1.01
			9751639		
VIR25				0	1.06
			9751401		
VIR27	0	1.06		9751401	

VIR30	0	1.06	9751401
VIR32	+6	1.14	9751639
VIR38	0	0.95	9751639
VIR39	0	0.95	9751639
VIR60	0	1.14	9751639
VIR60A	+6	1.20	9751639
VIR61	0	1.08	9751639
VIR65	+6	1.27	9751639
SA278	0	0.86	9755371
SA279	-18	0.86	9755371

1.4.2. Polygon nodes and water level corrections referencing San Juan, PR (9755371), Charlotte Amalie, St.Thomas (9751639), and Lime Tree Bay, St. Croix (9751401)) are provided in ASCII format denoted by a *.mix extension file name. Polygon nodes are also provided as a WordPerfect attachment. Zoning diagrams, created in MapInfo, are provided in both digital and hard copy format to assist with the zoning. Longitude and latitude coordinates are in decimal degrees. Negative (-) longitude is a MapInfo representation of West longitude.

APreliminary@ data for the control water level stations, San Juan, PR (9755371), Charlotte Amalie, St.Thomas (9751639), and Lime Tree Bay, St. Croix (9751401) , are available in near real-time and verified data will be available on a weekly basis for the previous week. These water level data may be obtained from the CO-OPS web site at http://co-ops.nos.noaa.gov/. From this site, click on AWater Level Observations@ to obtain preliminary or verified/historical water level data. You may access these water level data option directly at http://co-ops.nos.noaa.gov/data_res.html.

1.5. Final Zoning

1.5.1. For final processing, apply tidal zoning correctors to Averified@ observed data of the NOS control station and/or the final processed data of the subordinate stations. The final zoning scheme in MapInfo[7] or ArcView[7] digital format and all data utilized in its development shall be documented and submitted to CO-OPS at the address referenced in section 1.3.2.1. Refer to Section 1.1. for details.

Appendix D. Patch Test Report

Calibration Date: February 1 and February 5, 2005

Ship	NOAA Ship Nancy Foster
Vessel	
Echosounder System	Reson 8101-ER
Positioning System	POS/MV Model 320 Version 3
Attitude System	POS/MV Model 320 Version 3

Calibration type:

Annual		Full	
Installation	X	Limited/Verification	
System change			
Periodic/QC			
Other:			

The following calibration report documents procedures used to measure and adjust sensor biases and offsets for multibeam echosounder systems. Calibration must be conducted A) prior to CY survey data acquisition B) after installation of echosounder, position and vessel attitude equipment C) after changes to equipment installation or acquisition systems D) whenever the Hydrographer suspects incorrect calibration results. The Hydrographer shall periodically demonstrate that calibration correctors are valid for appropriate vessels and that data quality meets survey requirements. In the event the Hydrographer determines these correctors are no longer valid, or any part of the echosounder system configuration is changed or damaged, the Hydrographer must conduct new system calibrations.

Multibeam echosounder calibrations must be designed carefully and individually in consideration of systems, vessel, location, environmental conditions and survey requirements. The calibration procedure should determine or verify system offsets and calibration correctors (residual system biases) for draft (static and dynamic), horizontal position control (DGPS), navigation timing error, heading, roll, and pitch. Standard calibration patch test procedures are described in *Field Procedures for the Calibration of Multibeam Echo-sounding Systems*, by André Godin (Documented in Chapter 17 of the Caris HIPS/SIPS 5.3 User Manual, 2003). Additional information is provided in *POS/MV Model 320 Ver 3 System Manual* (10/2003), Appendix F, Patch Test, and the NOAA Field Procedures Manual (FPM, 2003). **The patch test method only corrects very basic alignment biases**. These procedures are used to measure static navigation timing error, transducer pitch offset, transducer roll offset, and transducer azimuth offset (yaw). Dynamic and reference frame biases can be investigated using a reference surface.

Pre-calibration Survey Information

Reference Frame Survey

(IMU, sensor, GPS antenna offsets and rotation with respect to vessel reference frame)

Vessel reference frame defined with respect to:

X IMU Reference ☐ Position

Reference to IMU Lever Arm

X(m)	Y(m)	Z(m)
0.0	0.0	0.0

IMU frame wrt vessel reference frame
Reference to Sensor Lever Arm

X(m)	Y(m)	Z(m)
-21.312	5.361	5.902

X **Measurements verified for this calibration.**
Reference Centerline Survey report
X **Drawing and table attached.**

☐ **Drawing and table included with project report/DAPR:**

Position/Motion Sensor Calibration (for POS/MV model 320 v3)

Calibration date: February 1, 2005

Reference to primary GPS Lever Arm

X(m)	Y(m)	Z(m)
-4.875	-5.104	-6.386

Heave Settings: Bandwidth 20.0 Damping Period .707

Reference to Heave Lever Arm (Assumed Axis of Rotation)

X(m)	Y(m)	Z(m)
-9.000	-1.115	2.642

Firmware version 2.16 was used for the entire survey.

Static Draft Survey

(Vessel waterline with respect to vessel reference frame)

Survey date: January 31, 2005

With the Nancy Foster tied up to the Molasses Pier in Port Alucroix, St. Croix, the survey team deployed the multibeam echosounder (mbes) for survey operations. Prior to conducting the patch test, initial confidence checks were conducted to ensure an accurate measurement of depths. The draft was determined initially by sighting the water level with the marks on the pole. The first check was to ensure the sonar was outputting a depth to our suspended bar accurately, and then to verify that the digital depths recorded were equally accurate. This is reflected in line Nfmba05032.d05. The digital depth was corrected for the heave component of the sonar associated with long lever arms to the inertial motion unit (imu). This heave component does not decay around zero, rather it is a constant bias with the vessel at rest. The second verification occurred with the leadline check to the seafloor while the vessel is at rest in calm seas. This check is recorded in line Nfmba05032.d07. The values associated with both checks follow.

Line	Raw Z(m)	Heave (m)	Corr. Z(m)	Observed Z(m)
*Nfmba05032.d05	4.92	-0.11	5.03	***5.04
**Nfmba05032.d07	9.93	-0.09	10.02	10.01

* 0.00 draft, 0.00 tide, 0.00 squat; bar @ 5.0m
** 3.35 draft, 0.00 tide, 0.00 squat; leadline=10.01m
*** Observed value subjectively determined from Reson monitor cursor placement

Throughout the survey, the static draft changed due to fuel consumption and water discharge. These changes along with the initial 0.01 meter delta between the observed and corrected waterline check in file Nfmba05032.d07 are accounted for in the waterline table of the Hydrographic Vessel File NF_2005_zero.hvf

Static Draft Correction (meters) 3.35

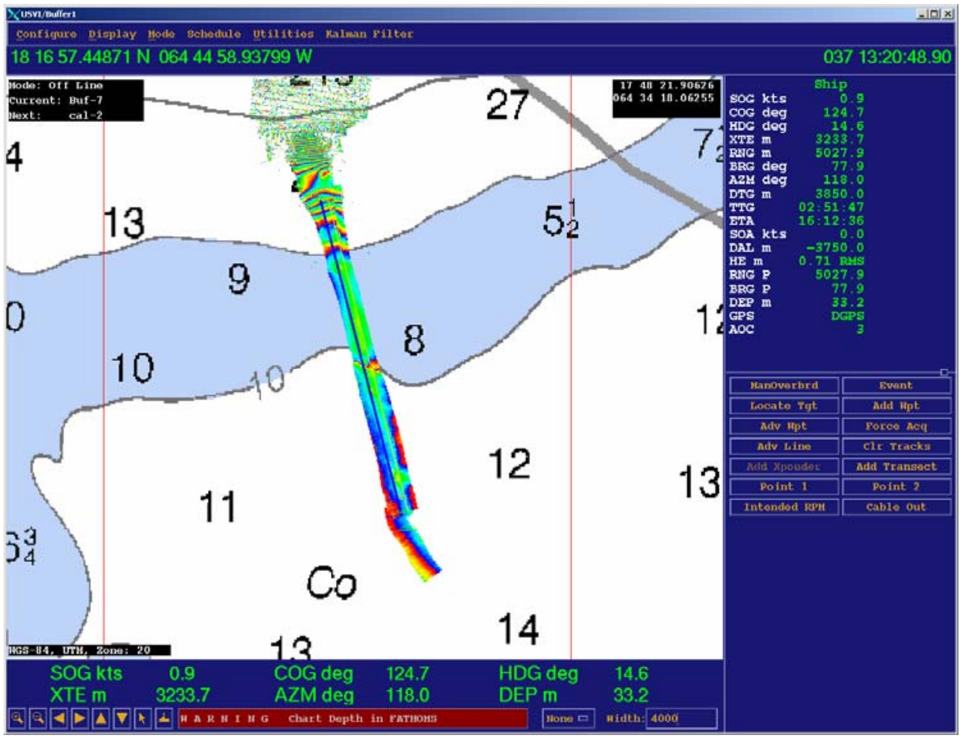
Dynamic Draft Survey
(Vessel waterline with respect to vessel reference frame and vessel speed)

No dynamic draft survey was conducted for this vessel.

Calibration Area

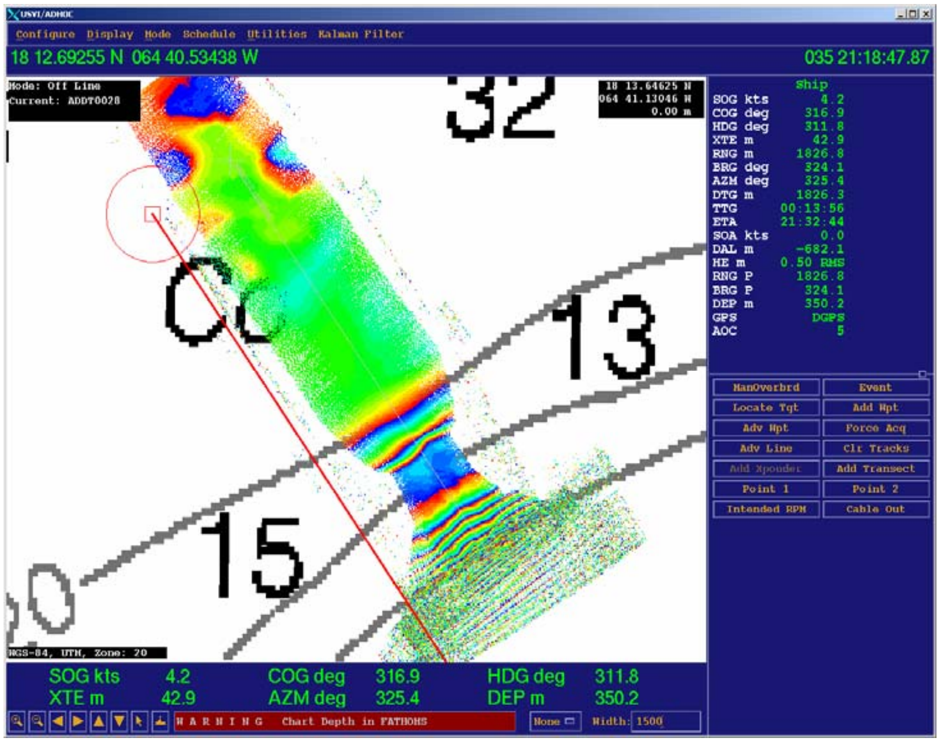
Site Description

On Julian Day 032 four lines of uncorrected multibeam data were collected along two transects east of Buck Island, St. Croix. Two lines on a reciprocal course upslope and over a sharp ledge provided the pitch offset, and the same lines run in a relatively flat area gave the roll bias. Offset to the initial transect was a single line to verify gyro bias. A final line was collected along the initial transect at slow speeds to identify timing error. The following image shows the initial patch test area as well as the coverage of the four patch test lines. The alignment bias can be observed in the contours during the initial patch test.

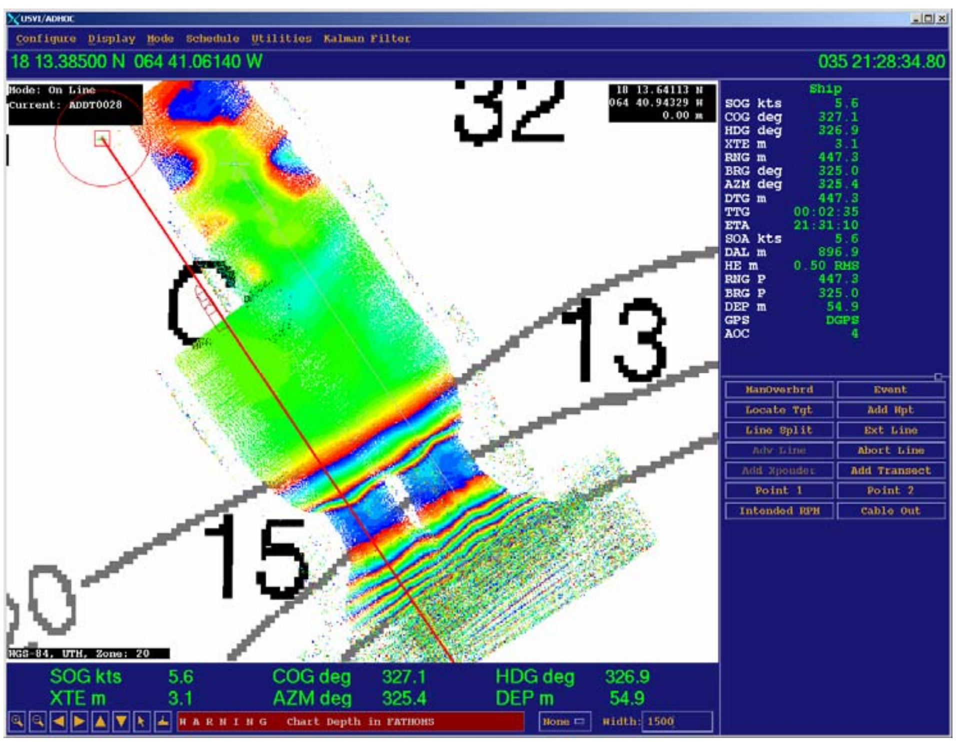


Initial Patch Site

Zero timing error was identified. This is consistent with the POS/MV operation principles. A pitch offset of -2.1° was detected. A roll bias of +0.9° was identified. A gyro bias of -5.0° was determined. The limiting factor to determining a more precise calibration was the depth of the area surveyed. The shoal depths result in a less than optimal calibration line set for observing bias. With that being said, the determined offsets proved to be pretty close to those determined in the deep water calibration set performed on Julian Day 035. A second patch test was going to be needed and an ideal location was identified at the shelf break south of St. John. Coincidentally, after the Grammanik East survey watch, an artifact was observed during heavy seas surveying with considerable roll. The artifact was attributed to flex in the sonar pole. As a precautionary action, the pole was pivoted into its cradle and visually inspected. Upon completing the transit after the inspection, a deepwater modified patch test was conducted to both determine more precise bias offsets and ensure proper re-alignment. Three lines were run in a similar fashion to the initial three in the beginning patch test. Pitch and roll lines ran reciprocally over a reef crest and flat bottom. The gyro bias was again observed with a line ran offset and upslope as shown in the figure above. Minor adjustments to the initial determined values were made resulting in a pitch value of -1.8°, roll value of +0.83°, and gyro of –4.0°. The initial values remained in the acquisition software and the adjustments were to be applied in post-processing. The question to be answered was whether or not back applying the new values to the data collected prior to the pole inspection would be required.



Deepwater Patch Site Reciprocal Lines



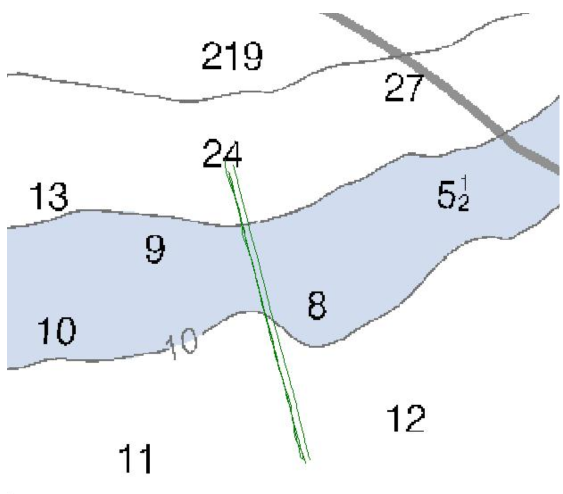
Deepwater Patch Site Offset Lines

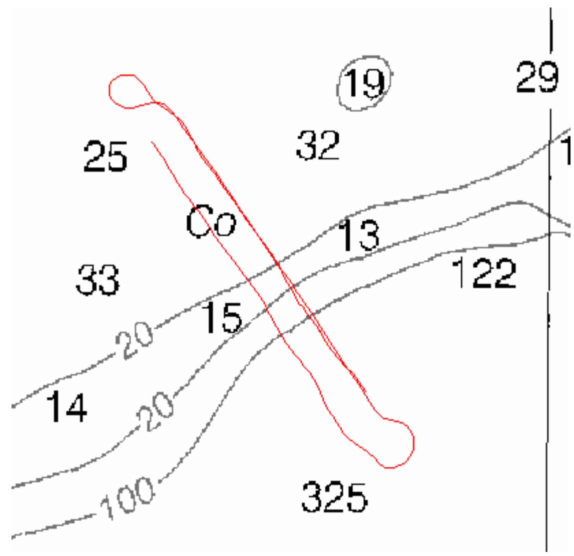
The Hydrographer tested the new values against the earlier data and determined that a noticeable improvement to feature alignment was observed and that the adjustments would be back applied to the entire dataset. This resulted in a change to the HVF and is observed in a new timestamp later than the initial stamp but prior to the start of acquisition. During testing, a problem with the processing software was detected. Apparently during conversion from raw multibeam to HDCS data, the gyro bias value was not being read. Considerable tests were conducted with varying gyro offsets to come to this conclusion. It is for this reason that the –4.0° gyro offset is being applied in the HVF and not the +1.0° adjustment between the initially determined offset and the adjusted value.

Site and Line Diagram

X Submarine Feature

The feature ensonified for the purpose of sensor calibration in both the shallow and deep-water patch tests was a reef crest. The reef crest for the shallow water patch test was located at 17°47’40”N and 64°33’24”W. The reef crest for the deep-water patch was located at 18°13’12”N and 64°40’51”W. The depths used for the roll determination on the shallow water patch were 23 meters. The depths for the deep-water roll were 56 meters. The following images depict the actual lines going over the actual features.





All patch test lines cross the same features. The left image depicts the shallow patch test. Line 1 is the line to the west. The image to the right depicts the deep patch test. Line 1 is the line to the east. The table of calibration lines below details the methodology for determining sensor offset values.

Calibration Lines

Raw GSF	HDCS	Line	Azimuth	Speed	Latency	Pitch	Roll	Gyro
Nfmba05032.d13	Nfmba05032_d13	1	165°	6.0		x	x	
Nfmba05032.d17	Nfmba05032_d17	1	345°	6.0	x	x	x	x
Nfmba05032.d19	Nfmba05032_d19	2	165°	6.0				x
Nfmba05032.d21	Nfmba05032_d21	1	345°	3.0	x			
Nfmba05035.d11	Nfmba05035_d11	1	325°	5.0		x	x	
Nfmba05035.d12	Nfmba05035_d12	1	145°	6.0		x	x	x
Nfmba05035.d13	Nfmba05035_d13	2	325°	5.0				x

X **Copy of acquisition logs attached.**

Sound Velocity Correction

Measure water sound velocity (SV) prior to survey operations in the immediate vicinity of the calibration site. Conduct SV observations as often as necessary to monitor changing conditions and acquire a SV observation at the conclusion of calibration proceedings. If SV measurements are measured at the transducer face, monitor surface SV for changes and record surface SV with profile measurements.

Sound Velocity Measurements

Cast	Time	Depth(m)	Sfc Velocity(m/s)	Latitude	Longitude
2005032-01	1500	120	1537	17°48' 03" N	64°33' 43" W
2005035-03	2014	150	1537	18°12' 57" N	64°40' 31" W

Tide Correction

Gauge ID Predicted tides not applied.

Approximate distance of gauge from calibration site: (n. mi.) N/A

Approximate water level range at calibration site: .050 **(meters)**

Water level corrections applied:

☐ Predicted Verified ☐
☐ Preliminary
☐ Zoned Note: Patch was processed without tides. No discernible tide occurred during patch test based on predicted values. Post-patch data acquired with zoned predicted tides. Smooth tides will be applied during post-processing.

Data Acquisition and Processing Guidelines

Initially, calibration measurement offsets should be set to zero in vessel configuration files. Static and dynamic draft offsets, inertial measurement unit (IMU) lever arm offsets, and vessel reference frame offsets must be entered in appropriate software applications prior to bias analysis. Perform minimal cleaning to eliminate gross flyers from sounding data.

Navigation Timing Error (NTE)

Measure NTE correction through examination of a profile of the center beams from lines run in the same direction at maximum and minimum vessel speeds. NTE is best observed in shallow water.

Transducer Pitch Offset (TPO)

Apply NTE correction. Measure TPO correction through examination of a profile of the center beams from lines run up and down a bounded slope or across a conspicuous feature. Acquire data on lines oriented in opposite directions, at the same vessel speed. TPO is best observed in deep water.

Transducer Roll Offset (TRO)

Apply NTE and TPO corrections. Measure the TRO correction through examination of roll on the outer beams across parallel overlapping lines. TRO is best observed over flat terrain in deep water. An additional check for TRO adjustment can be performed by running two lines parallel to a sloped surface.

Transducer Azimuth Offset (TAO or yaw)

Apply NTE, TPO and TRO corrections. Measure TAO correction through examination of a conspicuous topographic feature observed on the outer beams of lines run in opposite directions.

Patch Test Results and Correctors

Evaluator	NTE (sec)	TPO (deg)	TAO (deg)	TRO (deg)
Jay Lazar	0.0	-1.80	-4.00	+0.83
Final Values	**0.0**	**-1.80**	**-4.00**	**+0.83**

Corrections calculated in: CARIS HIPS

[X] Caris ISIS [ ]

[ ] Other __________________

Caris Vessel Configuration File

Name: NF_2005_patch.hvf (1), NF_2005_zero.hvf (2)

Version: 5.4 SP 1 HF 20

New [X] Appended values with time [ ] tag

Comments:
Improvements to the sonar pole mount and accurate assessment of sensor offsets have created confidence in the values determined during the patch test. The second patch test in deep water afforded the opportunity to improve upon the initial values and allowed for greater confidence in the survey.

Additional calibration or action recommended:

____

____

Evaluator: ___John V. Lazar Jr._______________________

Reviewed by: ______________________________

Accepted by: ______________________________

Appendix E. Hardware and Software Settings

Reson Menu Settings

Main
MaxRate: 30.0 p/s
TxPulse: 79 us
GainMode: TVG
AutoGain: 1

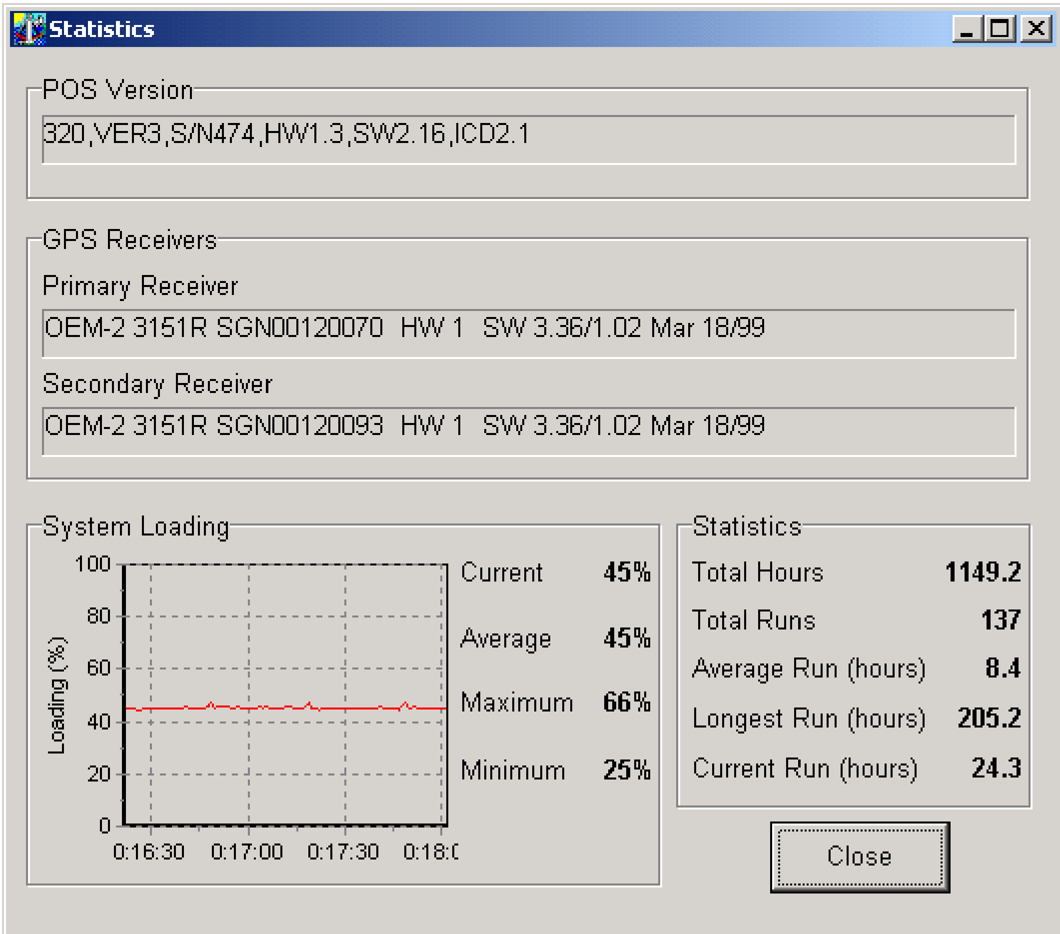
Filters
None

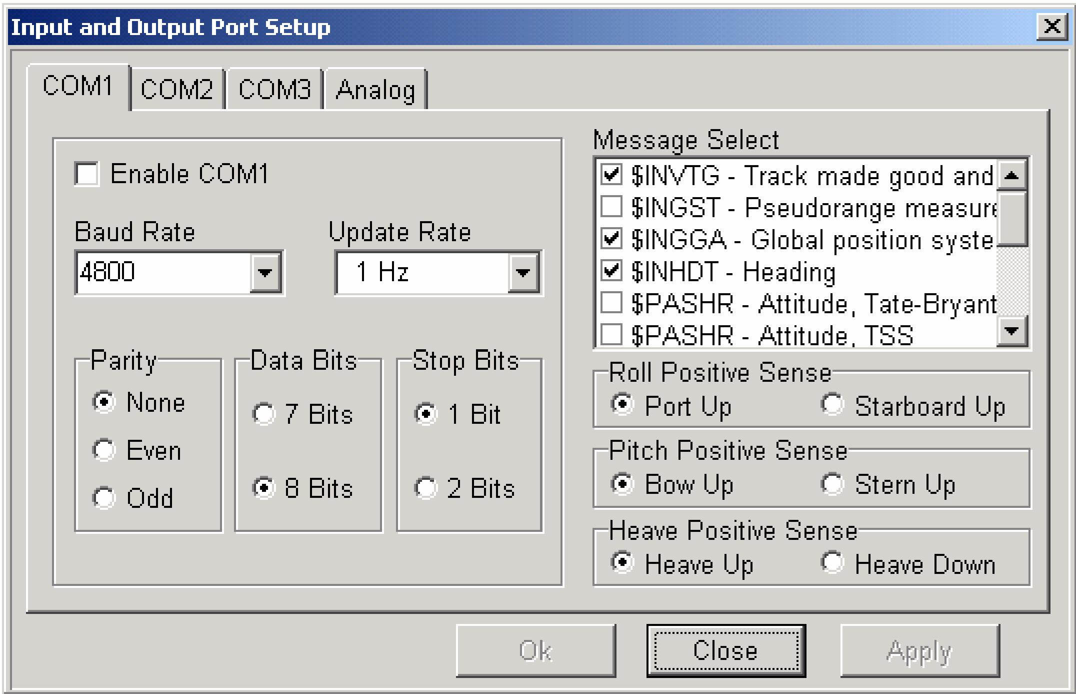
Ocean
Spread: 30 log dB
Absorb: 70 dB/km
Velocity: 1490 m/s

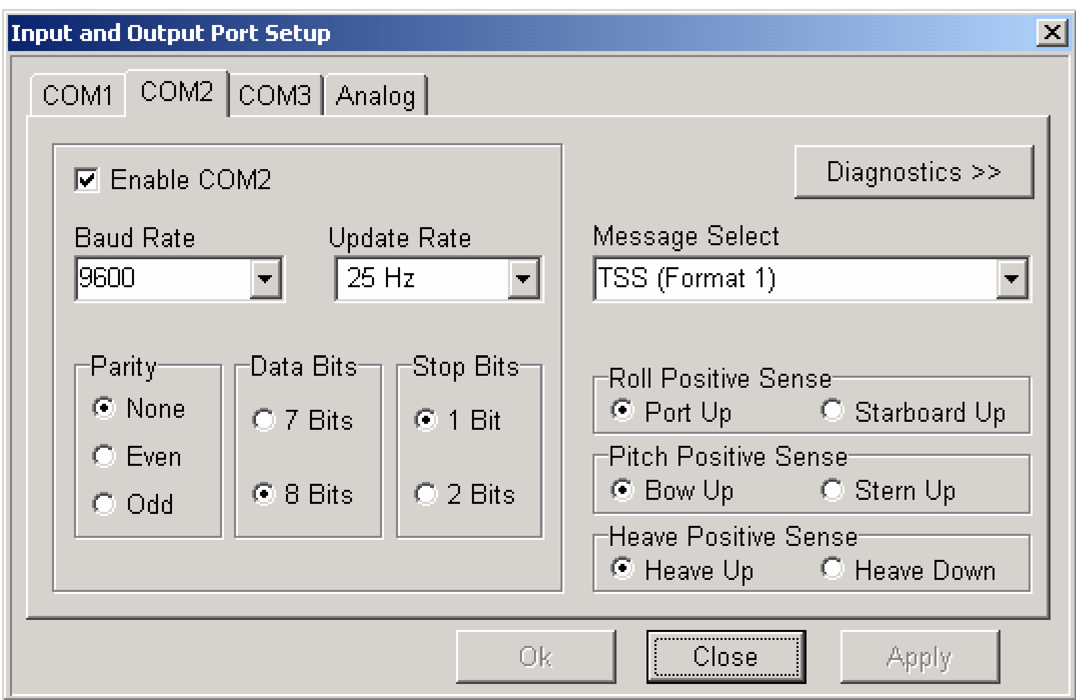
Modes
Format: RI0
Sidescan: Full-New
Snippets: Flatbottom
Projector: E-R
PitchStab: Off
RollStab: Off

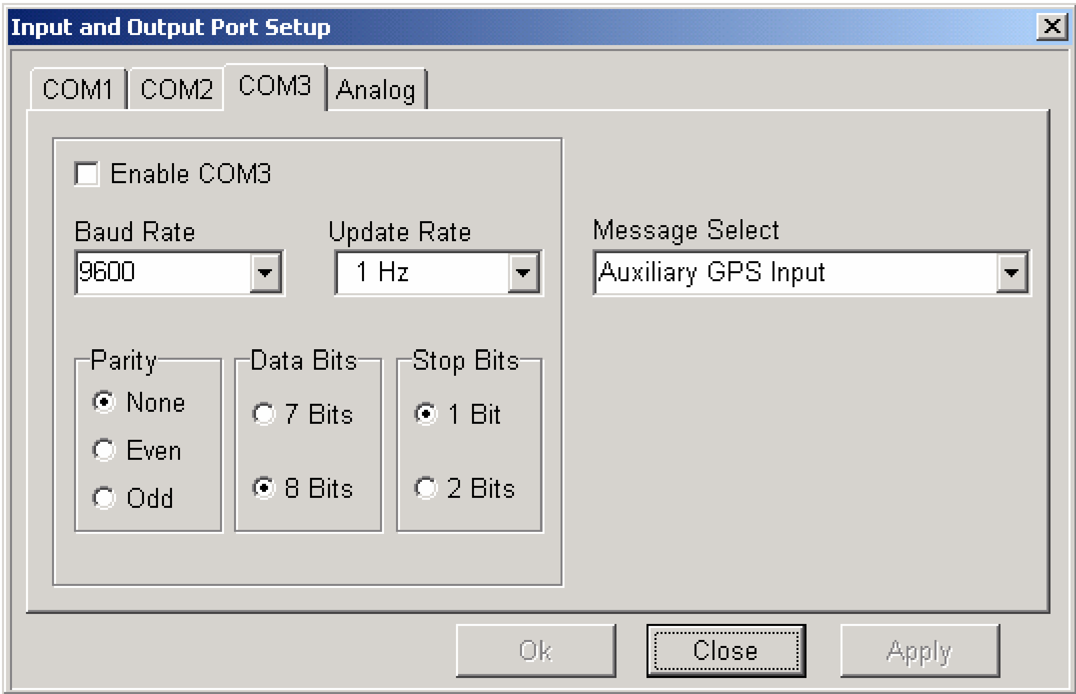
Config
Uplink: Coax1
Output: Ethernet
ProfilBd: 115200
TimeBd: 115200
ContrlBd: 115200
MotionBd: 9600
VelctyBd: 9600
UDP Base:5000
Oriented: ProjAft
HeadSync: OneHead

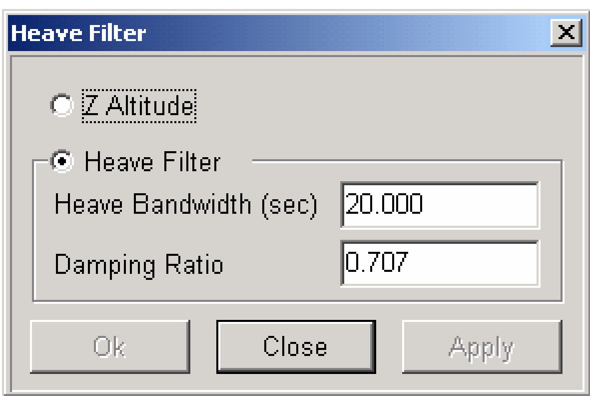
POS MV Settings

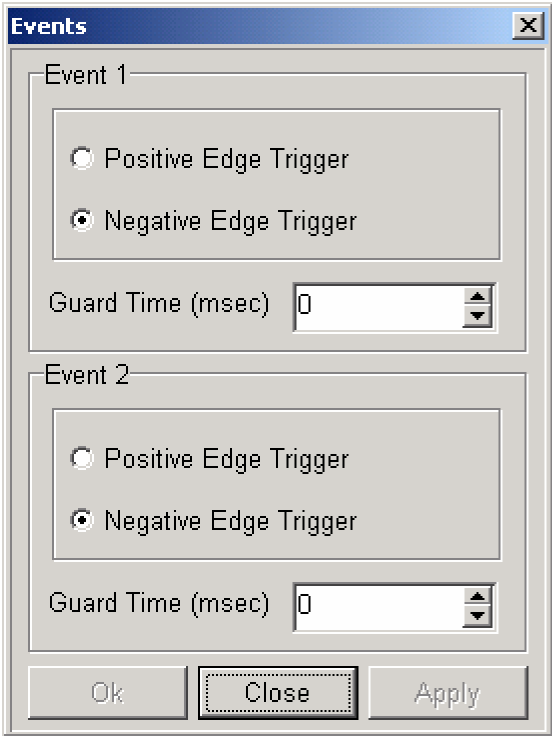


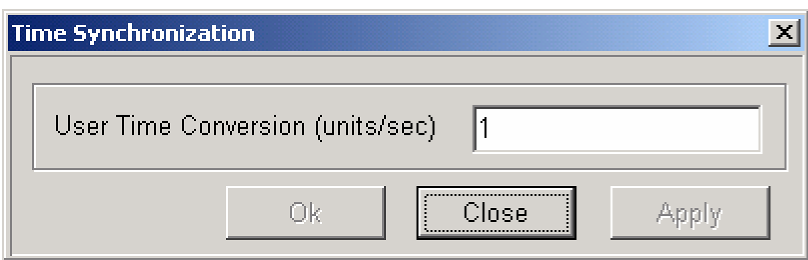

Input and Output Port Setup
COM1
COM2
COM3
Analog
Enable COM1
Baud Rate
4800
Update Rate
1 Hz
Parity
None
Even
Odd
Data Bits
7 Bits
8 Bits
Stop Bits
1 Bit
2 Bits
Message Select
$INVTG - Track made good and
$INGST - Pseudorange measure
$INGGA - Global position syste
$INHDT - Heading
$PASHR - Attitude, Tate-Bryant
$PASHR - Attitude, TSS
Roll Positive Sense
Port Up
Starboard Up
Pitch Positive Sense
Bow Up
Stern Up
Heave Positive Sense
Heave Up
Heave Down
Ok
Close
Apply

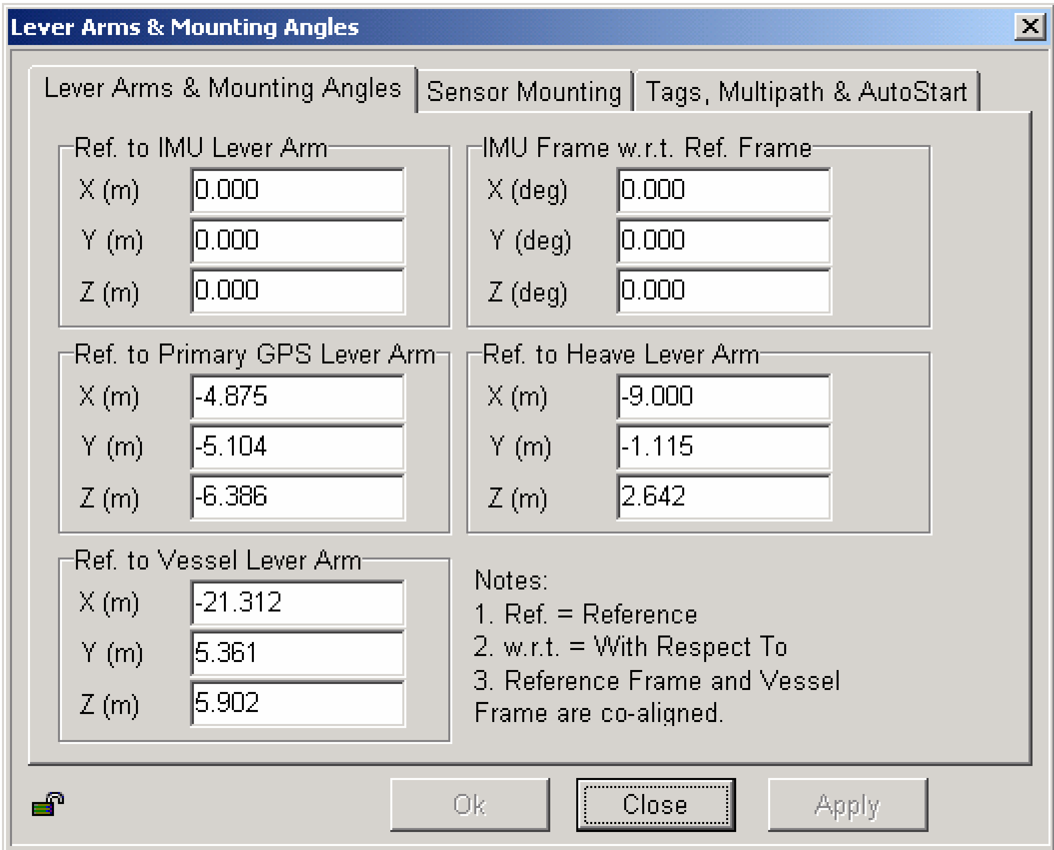

Input and Output Port Setup
COM1
COM2
COM3
Analog
Enable COM2
Baud Rate
9600
Update Rate
25 Hz
Parity
None
Even
Odd
Data Bits
7 Bits
8 Bits
Stop Bits
1 Bit
2 Bits
Diagnostics >>
Message Select
TSS (Format 1)
Roll Positive Sense
Port Up
Starboard Up
Pitch Positive Sense
Bow Up
Stern Up
Heave Positive Sense
Heave Up
Heave Down
Ok
Close
Apply

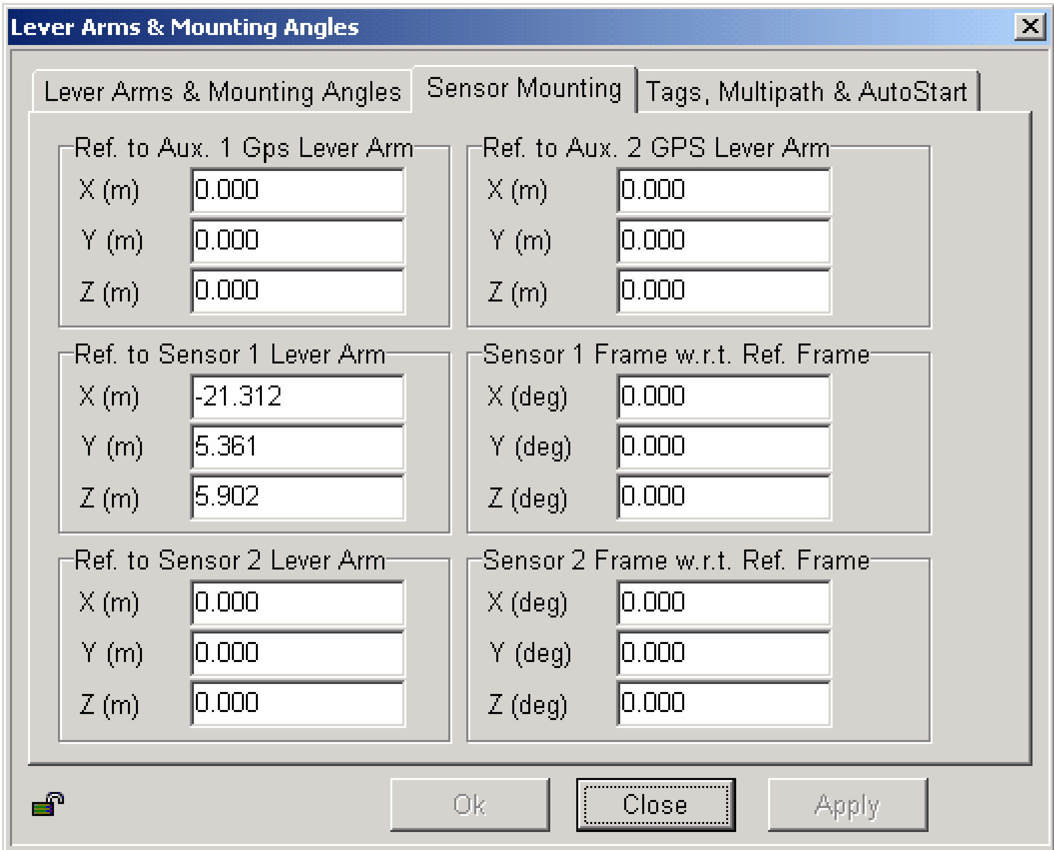

Input and Output Port Setup
COM1
COM2
COM3
Analog
Enable COM3
Baud Rate
9600
Update Rate
1 Hz
Message Select
Auxiliary GPS Input
Parity
None
Even
Odd
Data Bits
7 Bits
8 Bits
Stop Bits
1 Bit
2 Bits
Ok
Close
Apply

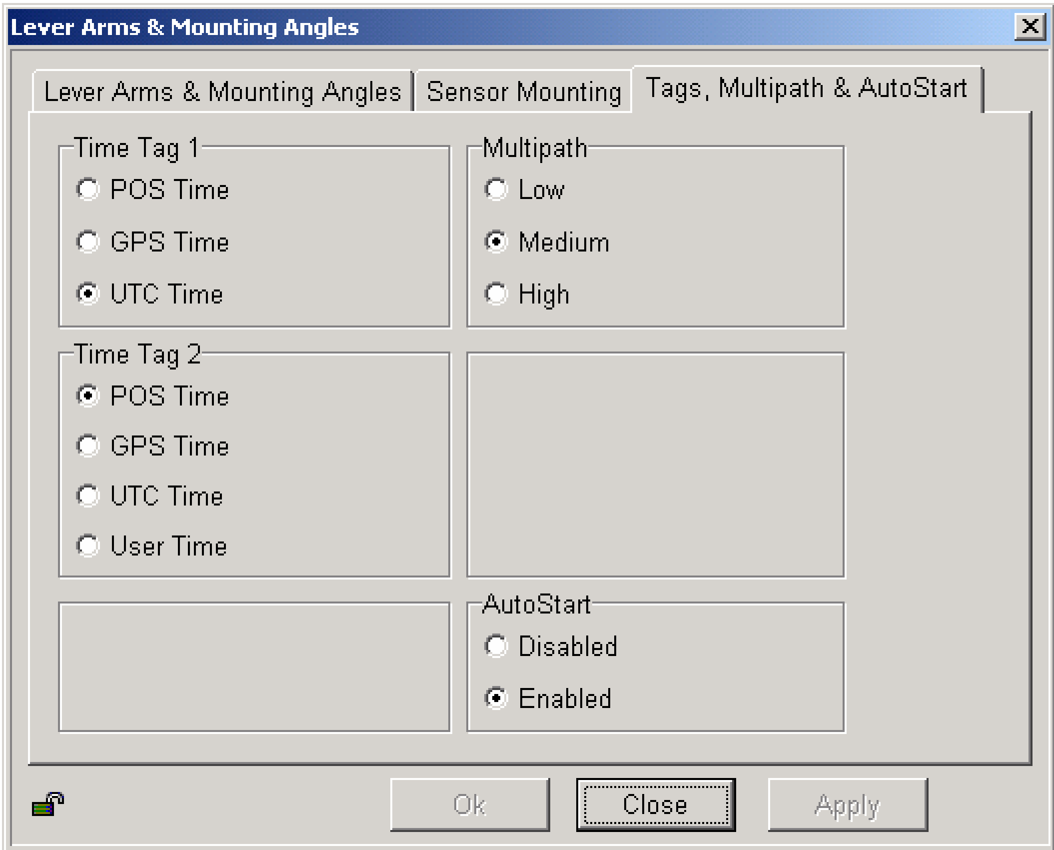

Heave Filter
Z Altitude
Heave Filter
Heave Bandwidth (sec)
20.000
Damping Ratio
0.707
Ok
Close
Apply

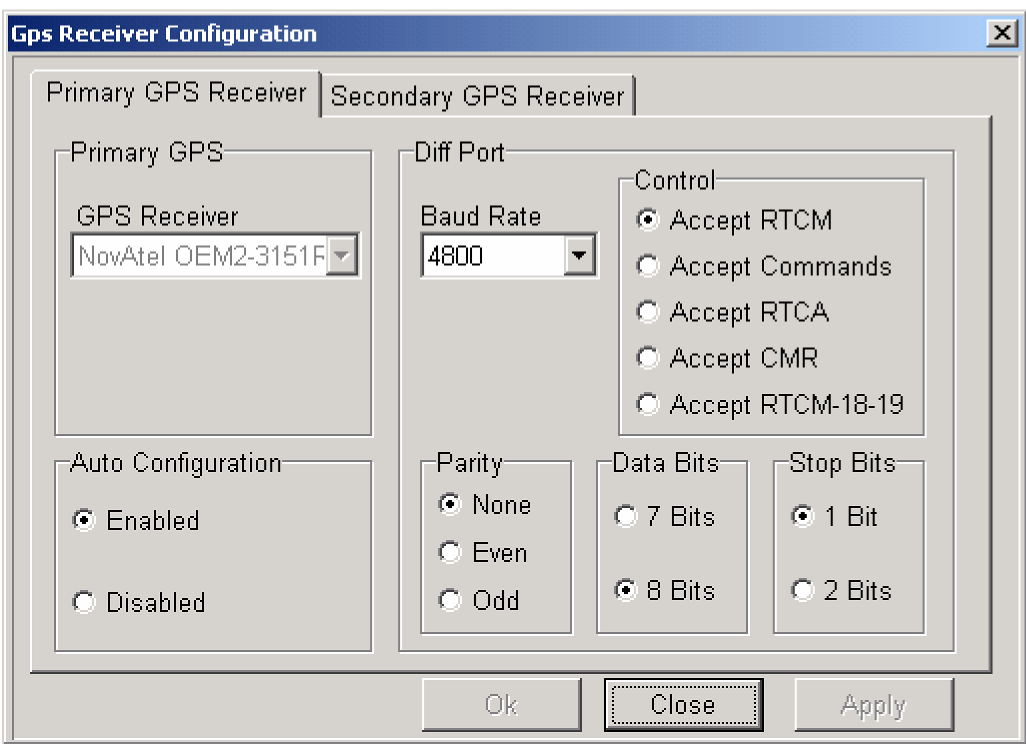

Events
Event 1
Positive Edge Trigger
Negative Edge Trigger
Guard Time (msec)
0
Event 2
Positive Edge Trigger
Negative Edge Trigger
Guard Time (msec)
0
Ok
Close
Apply

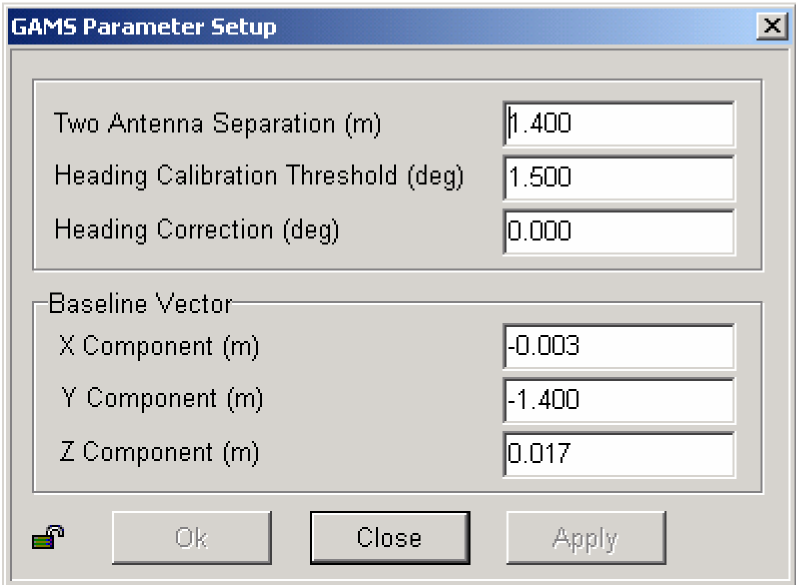

Time Synchronization
User Time Conversion (units/sec)
1
Ok
Close
Apply

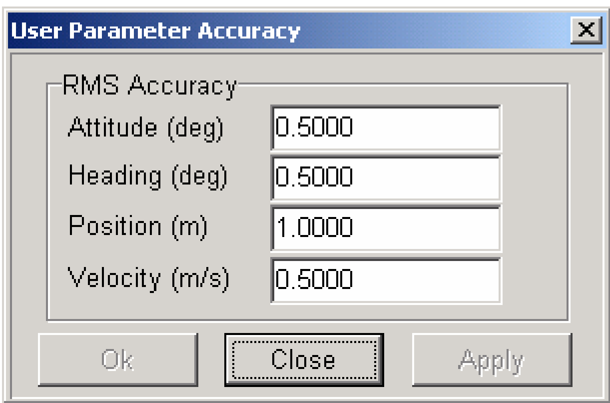

Lever Arms & Mounting Angles
Lever Arms & Mounting Angles
Sensor Mounting
Tags, Multipath & AutoStart
Ref. to IMU Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
IMU Frame w.r.t. Ref. Frame
X (deg) 0.000
Y (deg) 0.000
Z (deg) 0.000
Ref. to Primary GPS Lever Arm
X (m) -4.875
Y (m) -5.104
Z (m) -6.386
Ref. to Heave Lever Arm
X (m) -9.000
Y (m) -1.115
Z (m) 2.642
Ref. to Vessel Lever Arm
X (m) -21.312
Y (m) 5.361
Z (m) 5.902
Notes:
1. Ref. = Reference
2. w.r.t. = With Respect To
3. Reference Frame and Vessel
Frame are co-aligned.
Ok
Close
Apply


Lever Arms & Mounting Angles
Lever Arms & Mounting Angles
Sensor Mounting
Tags, Multipath & AutoStart
Ref. to Aux. 1 Gps Lever Arm
X (m)
0.000
Y (m)
0.000
Z (m)
0.000
Ref. to Aux. 2 GPS Lever Arm
X (m)
0.000
Y (m)
0.000
Z (m)
0.000
Ref. to Sensor 1 Lever Arm
X (m)
-21.312
Y (m)
5.361
Z (m)
5.902
Sensor 1 Frame w.r.t. Ref. Frame
X (deg)
0.000
Y (deg)
0.000
Z (deg)
0.000
Ref. to Sensor 2 Lever Arm
X (m)
0.000
Y (m)
0.000
Z (m)
0.000
Sensor 2 Frame w.r.t. Ref. Frame
X (deg)
0.000
Y (deg)
0.000
Z (deg)
0.000
Ok
Close
Apply

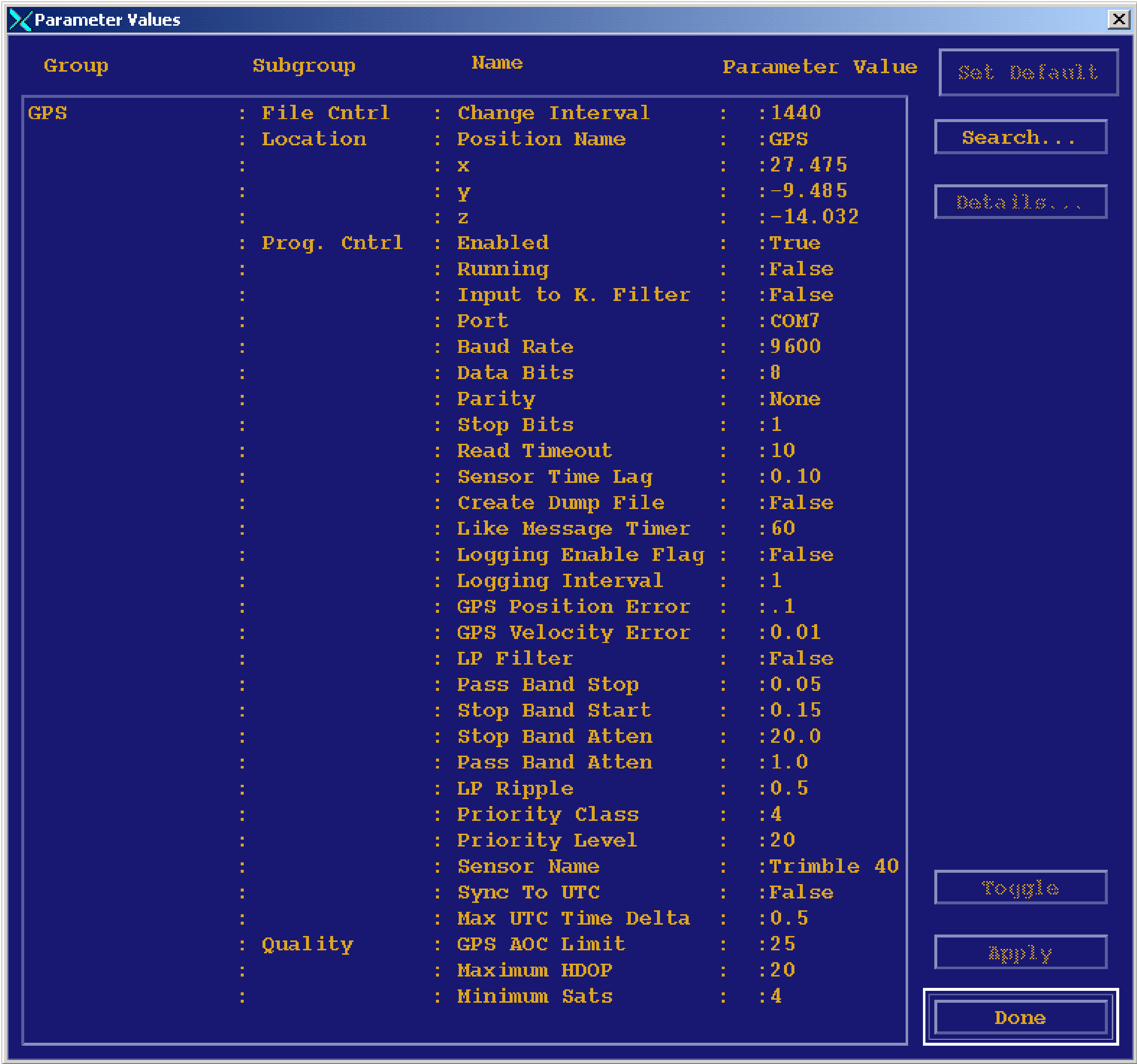

Lever Arms & Mounting Angles
Lever Arms & Mounting Angles
Sensor Mounting
Tags, Multipath & AutoStart
Time Tag 1
POS Time
GPS Time
UTC Time
Multipath
Low
Medium
High
Time Tag 2
POS Time
GPS Time
UTC Time
User Time
AutoStart
Disabled
Enabled
Ok
Close
Apply


Gps Receiver Configuration
Primary GPS Receiver
Secondary GPS Receiver
Primary GPS
GPS Receiver
NovAtel OEM2-3151F
Diff Port
Baud Rate
4800
Control
Accept RTCM
Accept Commands
Accept RTCA
Accept CMR
Accept RTCM-18-19
Auto Configuration
Enabled
Disabled
Parity
None
Even
Odd
Data Bits
7 Bits
8 Bits
Stop Bits
1 Bit
2 Bits
Ok
Close
Apply


GAMS Parameter Setup
Two Antenna Separation (m)
1.400
Heading Calibration Threshold (deg)
1.500
Heading Correction (deg)
0.000
Baseline Vector
X Component (m)
-0.003
Y Component (m)
-1.400
Z Component (m)
0.017
Ok
Close
Apply

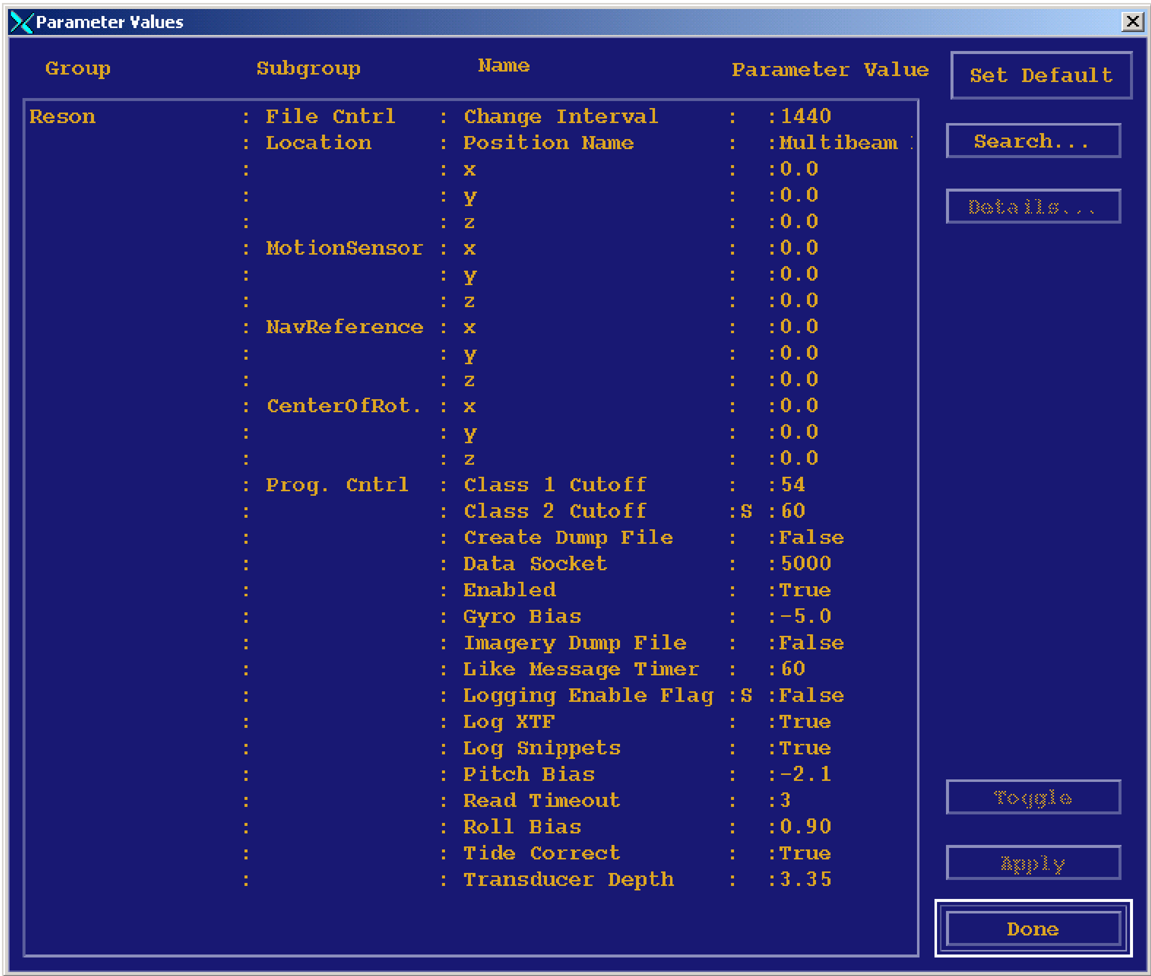

User Parameter Accuracy
RMS Accuracy
Attitude (deg)
0.5000
Heading (deg)
0.5000
Position (m)
1.0000
Velocity (m/s)
0.5000
Ok
Close
Apply

ISS 2000 Acquisition Settings

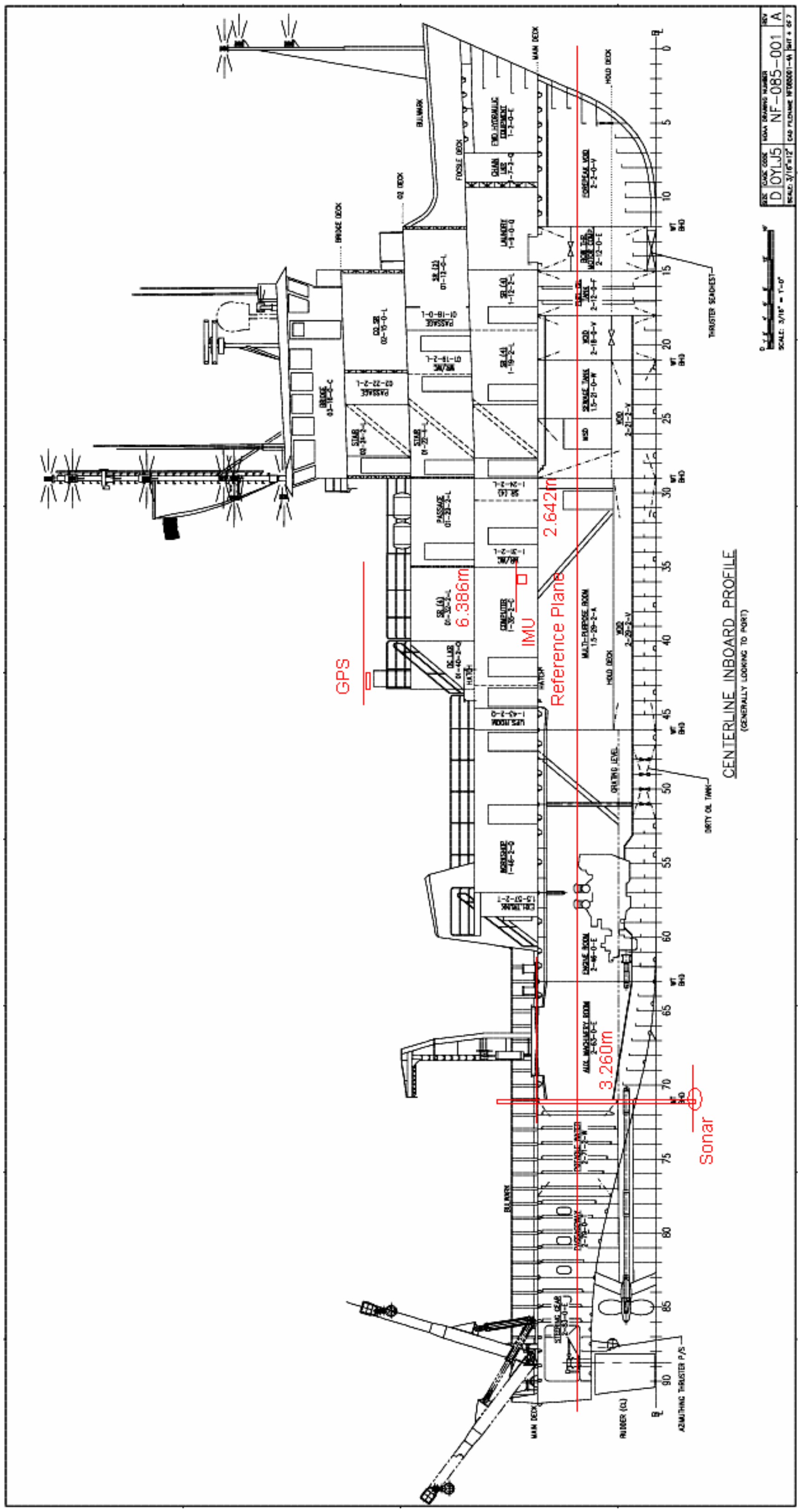


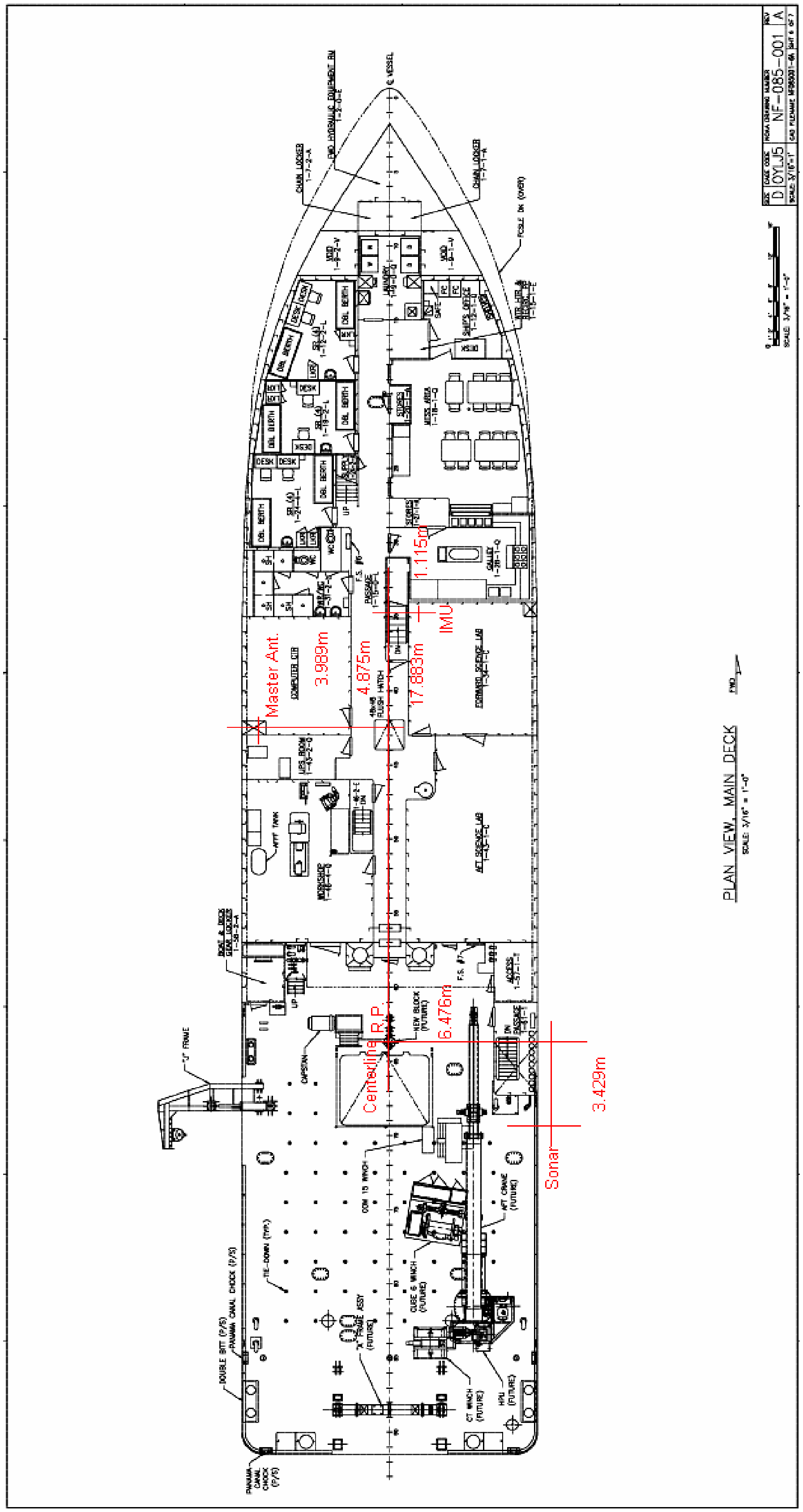
Group	Subgroup	Name	Parameter Value
GPS	File Cntrl	Change Interval	1440
	Location	Position Name	GPS
		x	27.475
		y	-9.485
		z	-14.032
	Prog. Cntrl	Enabled	True
		Running	False
		Input to K. Filter	False
		Port	COM7
		Baud Rate	9600
		Data Bits	8
		Parity	None
		Stop Bits	1
		Read Timeout	10
		Sensor Time Lag	0.10
		Create Dump File	False
		Like Message Timer	60
		Logging Enable Flag	False
		Logging Interval	1
		GPS Position Error	.1
		GPS Velocity Error	0.01
		LP Filter	False
		Pass Band Stop	0.05
		Stop Band Start	0.15
		Stop Band Atten	20.0
		Pass Band Atten	1.0
		LP Ripple	0.5
		Priority Class	4
		Priority Level	20
		Sensor Name	Trimble 40
		Sync To UTC	False
		Max UTC Time Delta	0.5
	Quality	GPS AOC Limit	25
		Maximum HDOP	20
		Minimum Sats	4

Parameter Values
Group
Subgroup
Name
Parameter Value
Set Default
Search...
Details...
POSMV : File Cntrl : Change Interval : :1440
: Prog. Cntrl : Create Dump File : :False
: : Enabled : :True
: : Input to K. Filter : :True
: : Like Message Timer : :1800
: : Logging Enable Flag : :False
: : Logging Interval : :0.5
: : Read Timeout : :10.000000
: : Receive Data Socket : :5602
: : Running : :False
: : Sensor Name : :POSMV
: Quality : DGPS Corr Latency : :20
: : HDOP Limit : :5
: : SV Tracked Limit : :4
: : Heading Limits : :360
: : Heave Limits : :25.5
: : Pitch Limits : :30
: : Roll Limits : :45
: : Velocity Limits : :20
: : RMS Pos Error : :2.0
: : RMS Vel Error : :.45
: : RMS Heading Error : :0.5
: : RMS Pitch Error : :.5
: : RMS Roll Error : :.5
Toggle
Apply
Done


Parameter Values
Group Subgroup Name Parameter Value
Set Default
Search...
Details...
Reson : File Cntrl : Change Interval : :1440
: Location : Position Name : :Multibeam
: : x : :0.0
: : y : :0.0
: : z : :0.0
: MotionSensor : x : :0.0
: : y : :0.0
: : z : :0.0
: NavReference : x : :0.0
: : y : :0.0
: : z : :0.0
: CenterOfRot. : x : :0.0
: : y : :0.0
: : z : :0.0
: Prog. Cntrl : Class 1 Cutoff : :54
: : Class 2 Cutoff :S :60
: : Create Dump File : :False
: : Data Socket : :5000
: : Enabled : :True
: : Gyro Bias : :-5.0
: : Imagery Dump File : :False
: : Like Message Timer : :60
: : Logging Enable Flag :S :False
: : Log XTF : :True
: : Log Snippets : :True
: : Pitch Bias : :-2.1
: : Read Timeout : :3
: : Roll Bias : :0.90
: : Tide Correct : :True
: : Transducer Depth : :3.35
Toggle
Apply
Done

Appendix F. Vessel Offset Diagrams




Master Ant.
3.989m
4.875m
17.883m
1.115m
IMU
Centerline R.P.
6.476m
3.429m
Sonar
PLAN VIEW, MAIN DECK
NF-085-001

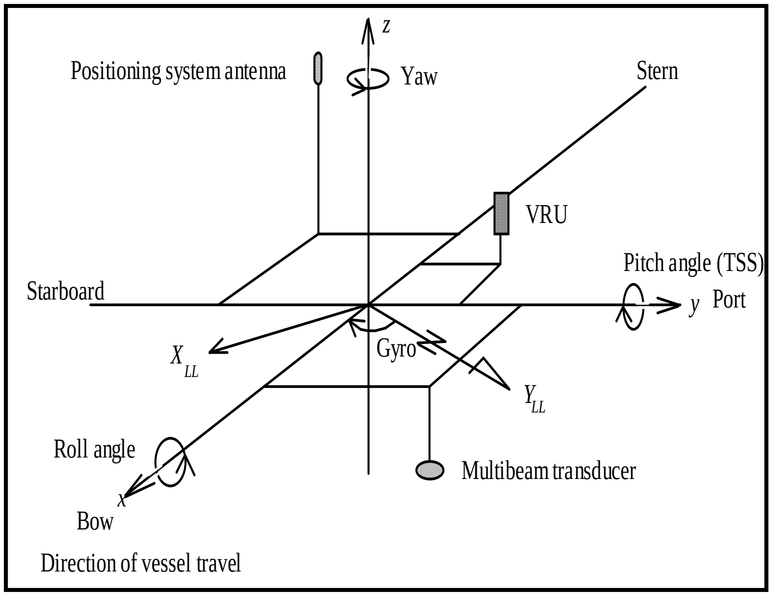
Appendix G. Hare Analysis Vessel Configurations Worksheets

30m

Input data area

All errors at 68% confidence

General	
Vessel	VOO
Vessel noise (dB)	0
Sounding speed (knots)	6.0
Swath overlap (percent)	20
Speed error (m/s)	0.1
VRU	POS?
Heading sensor/gyro	POS?
Positioning system	POS?
Velocimeter or CTD	Seabird SBE-19
Surface sound speed sensor	NA
Sensor coordinate offsets	
Positioning X (m)	-4.875
Positioning Y (m)	-5.104
Positioning Z (m)	-6.386
VRU X (m)	0.000
VRU Y (m)	0.000
VRU Z (m)	0.000
Transducer X (m)	-21.310
Transducer Y (m)	5.360
Transducer Z (m)	5.910
Roll offset angle of transducer (deg)	0.87
Pitch offset angle of transducer (deg)	-1.80
Heading offset angle of transducer (deg)	-4.00
Transducer Draft (m)	3.340
Auxilliary sensor errors	
Heave - fixed error (m)	0.05
Heave (% error of heave Amplitude)	5.00
Roll (deg)	0.05
Pitch (deg)	0.05
Auxilliary sensor offset errors (from patch test)	
Roll (deg)	0.03
Pitch (deg)	0.03
Yaw (deg)	0.03



Positioning errors

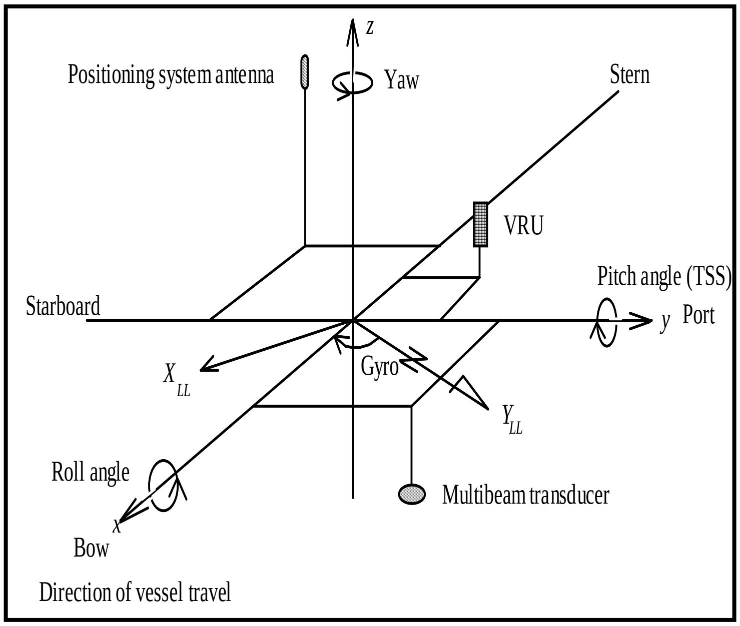
General	
Positioning system error (m) drms	1.00
Heading error (deg)	0.05
Sensor coordinate offset errors	
Positioning X (m)	0.100
Positioning Y (m)	0.100
Positioning Z (m)	0.100
VRU X (m)	0.030
VRU Y (m)	0.030
VRU Z (m)	0.030
Transducer X (m)	0.100
Transducer Y (m)	0.100
Transducer Z (m)	0.100
Latency	
Positioning time lag (ms)	0.000
VRU time lag (s)	0.005
Transducer time lag (s)	0.005
Latency (s)	0.000

Reduction of soundings

Vessel-specific errors	
Draught error (m)	0.02
Squat error (m)	0.10
Loading changes (m)	0.02

50M

Input data area	
All errors at 68% confidence	
General	
Vessel	VOO
Vessel noise (dB)	0
Sounding speed (knots)	6.0
Swath overlap (percent)	20
Speed error (m/s)	0.1
VRU	POS?
Heading sensor/gyro	POS?
Positioning system	POS?
Velocimeter or CTD	Seabird SBE-19
Surface sound speed sensor	NA
Sensor coordinate offsets	
Positioning X (m)	-4.875
Positioning Y (m)	-5.104
Positioning Z (m)	-6.386
VRU X (m)	0.000
VRU Y (m)	0.000
VRU Z (m)	0.000
Transducer X (m)	-21.310
Transducer Y (m)	5.360
Transducer Z (m)	5.910
Roll offset angle of transducer (deg)	0.87
Pitch offset angle of transducer (deg)	-1.80
Heading offset angle of transducer (deg)	-4.00
Transducer Draft (m)	3.340
Auxilliary sensor errors	
Heave - fixed error (m)	0.05
Heave (% error of heave Amplitude)	5.00
Roll (deg)	0.05
Pitch (deg)	0.05
Auxilliary sensor offset errors (from patch test)	
Roll (deg)	0.03
Pitch (deg)	0.03
Yaw (deg)	0.03



Positioning errors	
General	
Positioning system error (m) drms	1.00
Heading error (deg)	0.05
Sensor coordinate offset errors	
Positioning X (m)	0.100
Positioning Y (m)	0.100
Positioning Z (m)	0.100
VRU X (m)	0.030
VRU Y (m)	0.030
VRU Z (m)	0.030
Transducer X (m)	0.100
Transducer Y (m)	0.100
Transducer Z (m)	0.100
Latency	
Positioning time lag (ms)	0.000
VRU time lag (s)	0.005
Transducer time lag (s)	0.005
Latency (s)	0.000

Reduction of soundings	
Vessel-specific errors	
Draught error (m)	0.02
Squat error (m)	0.10
Loading changes (m)	0.02